TRITON GREEN

Using Digital Technologies to Promote Sustainable Travel Behavior

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UC San Diego | SCRIPPS INSTITUTION OF OCEANOGRAPHY

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EXECUTIVE SUMMARY

Human activities are changing the earth's natural greenhouse effect. Since the industrial revolution, fossil fuel combustion has increased the concentration of greenhouse gases, such as carbon dioxide and methane, in the atmosphere. Changes in atmospheric carbon dioxide have already caused approximately 1.0 °C of global warming above pre-industrial levels. To avoid the most devastating consequences of anthropogenic climate change, universities, businesses, governments, states, and countries have made ambitious commitments to reduce greenhouse gas emissions. This capstone project offers a potential solution an app called Triton Green, to aid UC San Diego in meeting its carbon neutrality goals. The app employs a bottom-up approach, by encouraging individuals to switch to sustainable travel behaviors by using an interactive game with variable rewards. Triton Green applies digital technologies to integrate a range of sustainable modes of transportation into daily life. As part of the project, a commuter behavior survey was conducted among graduate students at UC San Diego to get a solid understanding of the current commuter habits, climate change attitudes, and motivations to take green travel options. The survey shows an inconsistency in personal climate change beliefs and daily commuter behavior. Based on the survey results, a blueprint of Triton Green was designed. Even though Triton Green could eventually help to reduce transportation emissions, combating anthropogenic climate change requires everyone, every state, and every nation to work together.

INTRODUCTION

Anthropogenic Climate Change

Climate Change 2013: The Physical Science Basis (2013) provides a robust conclusion that with 95 percent certainty, human activity, which has already caused approximately 1.0 °C of global warming above pre-industrial levels, is the leading cause of observed anthropogenic climate change since the mid-20th century. Greenhouse gas emissions, carbon dioxide from fossil fuel burning in particular, almost certainly contribute to such warming (Neeling, 2013). Solar radiation absorbed at the Earth's surface is emitted back into the atmosphere as infrared radiation. Greenhouse gas molecules, such as carbon dioxide and methane, are opaque to many wavelengths of infrared lights (NASA Earth Observatory, 2009). The temperature of greenhouse gas molecules increases as they absorb thermal infrared energy. Such molecules then emit an increased amount of thermal infrared energy in all directions, including the Earth surface (Archer, 2011; University Corporation for Atmospheric Research, 2012; NASA Earth Observatory, 2009). Among all types of greenhouse gases, carbon dioxide has the highest positive radiative forcing (except water vapor), which means the Earth receives a greater amount of incoming energy than it radiates to space (IPCC, 2013; NASA, n.d.). Moreover, carbon dioxide has a longer residence time in the atmosphere compare to other major heat-trapping gases once emitted by human activities (IPCC, 2013). These features make carbon dioxide a highly effective greenhouse gas that warms the planet, even though there is only a small fraction of such gas in the atmosphere (University Corporation for Atmospheric Research, 2011; University Corporation for Atmospheric Research, 2012; Archer, 2011). With an increasing

atmospheric concentration of carbon dioxide, more infrared radiation will be trapped, absorbed, and then emitted by the added carbon dioxide molecules contributing to further rises the temperature of the Earth surface (University Corporation for Atmospheric Research, 2011).

For decades, fossil fuel combustion has generated most of the energy required for electricity, industrial manufacturing, and transport (Denchak, 2018). Formed from fossilized organic materials for millions of years, such high carbon content resources have fueled global economic development over the past three centuries (Environmental and Energy Study Institute, 2019). While enjoying the benefits of fossil fuels, humankind has paid a heavy price. In 2017, approximately 32,310 million metric tons (MMT) of carbon dioxide were released into the atmosphere due to the burning of fossil fuel in the previous year (United States Environmental Protection Agency, 2019). The United States contributed approximately 15% of the carbon emissions, with 6,457 MMT of carbon dioxide equivalent (U.S. Energy Information Administration, 2019). In 2018, the total U.S. energy related carbon dioxide emissions were 5,259 MMT (U.S. Energy Information Administration, 2019) Almost half (45%) of the U.S. energy-related carbon dioxide emissions was resulted from petroleum fuels, most of which was contributed by the transportation sector since it was almost entirely dependent upon petroleum (United States Environmental Protection Agency, 2019).

In April 2018, the monthly atmospheric carbon dioxide concertation exceeded 410 parts per million (ppm) for the first time in the history of the Keeling Curve, which started at 315 ppm when the measurement series began in 1958 (Monroe, 2018). Since there is a time lag between carbon dioxide emissions and their impacts on the climate, the Earth has already committed to further warming (IPCC, 2018; Archer, 2011). *IPCC special Report - Summary for Policymakers* (2018) predicts that global warming is likely to reach 1.5 °C above pre-industrial levels between 2030 and 2052. The primary aim of the Paris Agreement is to limit the rise of the global temperature below 2 °C by the end of the 21st century to avoid the worst impacts of anthropogenic climate change (United Nations Framework Convention on Climate Change, 2019). However, a recent study claims that keeping the global temperature growth below 1.5 °C rather than 2 °C is far safer in a warming world. Main impacts of 2 °C of global warming compared to 1.5 °C are listed as follows.

- There will be more severe weather extremes, such as intense precipitations, heatwaves, and droughts;
- The global sea level rise will be 10 centimeters higher;
- Impacts on biodiversity and ecosystems, such as extinctions, will be higher;
- There will be increases in ocean temperature and the associated increases in ocean acidity and decreases in ocean oxygen levels; and,
- There will be increases in climate-related risks, including health, food security, water supply, and economic.

Despite scientific warning, carbon dioxide emissions continue to increase in recent years (United Nations, 2019a). Scientists (2019b) consent that the global greenhouse gas emissions must drop to 25 gigatons (Gt) by 2030 to achieve the 1.5°C warming goal. However, the present situation is less optimistic. The *Emission Gap Report* (2019) found that the greenhouse gas emissions would reach 56 Gt by 2030 if the world relies merely on the current commitments of the Paris Agreement. Under this circumstance, the mean global temperature rise is on the track to 3.2°C by the end of the 21st century (United Nations, 2019a). To limit the rise of global temperature to 1.5 ° C and avoid devastating effects of climate change, countries are required to collectively cut greenhouse gas emissions by 7.9% every year from 2020 to 2030 (United Nations, 2019b).

Halt Anthropogenic Climate Change with Behavior Change

Compared with the global carbon dioxide emissions from capital or governmental infrastructure investment, 72% of the worldwide greenhouse gases were emitted by the so-called "lifestyle" consumptions, such as housing, transportation, food, clothing, furniture and others (Hertwich and Peters, 2009; Fournier, Antes, and Beaumier, 1992). To meet the target of limiting the global temperature increase below 1.5 ° C, such lifestyle emissions must decrease to 2.5 tons of carbon dioxide equivalent (t CO_2e) per capita by 2030 and 0.7t CO_2e by 2050. However, the current lifestyle emissions are incompatible with the goal, with 10.4 t CO_2e for Finland, 4.2t CO_2e for China, and 2.0t CO_2e for India (World Resource Institute, 2019). Strong climate policies are essential to close the current emission gap. However, focusing on policy alone would reduce the possibility of taking urgent actions to

combat climate change since policy process takes time. Reducing carbon emissions also requires multiple actions from different actors across various sectors (Heller & Green, 2019). Even though governments set Nationally Determined Contributions (NDCs) on emission reduction targets, they require action by citizens. Research shows that voluntarily actions at the individual level can significantly reduce the overall carbon emissions, even in the absence of related-policies (Rare and California Environmental Associates, 2019). Scientists believe that behavior change of individuals can further influence how communities, business, governments, states, and countries act on halting anthropogenic climate change (Williamson, Satre-Meloy, Velasco, & Green, 2018).

Behavioral change has neglected to meet the global warming targets as well as to analyze mitigation solutions to climate change (Creutzig, et al., 2016), despite the necessity of driving behavioral change in transportation and energy sectors (Girod et al., 2013). The long-term climate strategies provide an opportunity for using multiple scenarios to simulate a version of what the future consistent with the global warming targets would look like (World Resource Institute, 2019). In *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming*, Paul Hawken (2017) calculated the carbon impacts of 80 solutions of anthropogenic climate change according to three scenarios, including solutions that are adopted at a realistically vigorous rate (Plausible Scenario) to solutions that achieve their maximum potential (Optimum Scenario). Williamson, Satre-Meloy, Velasco, and Green (2018) estimated the carbon emission reduction of 30 out of the 80 solutions that individuals and communities are willing to adopt. According to their

research, the total carbon emissions reduction potential was between 393 (Plausible Scenario) to 729 (Optimum Scenario) Gt of carbon dioxide-equivalent greenhouse gases during 2020 to 2050, 20% of which are contributed by green transportation behavior (Williamson, Satre-Meloy, Velasco, & Green, 2018). Thus, switching to sustainable modes of transportation could work as a potential solution to close the carbon emission gap and achieve the carbon reduction goal.

Behavioral change requires multidisciplinary studies across economics, political science, anthropology, psychology, and neuroscience (Williamson, Satre-Meloy, Velasco, & Green, 2018). Theoretical models can help with understanding how social and psychological factors influence individuals' behavior. The rational choice theory suggests that individuals are inclined to act on behavior that maximizes their expected utilities (Shepsle, 2010). Individuals make decisions after weighing the costs and benefits and take action that provide the maximum net benefits (Frick, 2007).

However, the prospect theory contends that individuals' decisions are not always rational and optimized (Kahneman, 2011). In the book *Thing, Fast and Slow*, Kahneman (2011) demonstrated that individuals are able to make rational and irrational decisions, both of which are valuable in different contexts. According to Kahneman (2011), there are two dominate ways of thinking, and Kahneman calls them as System 1 and System 2. System 1 is fast, automatic, emotional, and intuitive. It relies on cognitive shortcuts or heuristics and is responsible for biases in decision making. On the contrary, System 2 is controlled,

analytical, and deliberative, requiring time and efforts (Kahneman, 2011). Kahneman (2011) shows that the decision-making process is not based on perfect information and rational choices. Instead, it depends on psychological antecedents, including beliefs, values, social norms, daily routines, and even habits that are done with little or no conscious thoughts (Kahneman, 2011).

The environmental knowledge and attitude model emerged as one of the main strategies to impact behavior change (Williamson, Satre-Meloy, Velasco, & Green, 2018). Ramsey and Rickson (1976) found that education will lead to awareness and attitude change, which will further change behavior. However, there is a substantial body of research showing that awareness and attitude change, brought by educational campaigns, does not translate to behavior change (Schultz, 2002; Christiano & Neimand, 2017). Extrinsic motivation models indicate that behavior change could happen when individuals are granted with rewards (Eyal, 2014). However, it requires constant supply of such external incentives to maintain the same outcomes (Williamson, Satre-Meloy, Velasco, & Green, 2018).

Like extrinsic motivation, intrinsic incentives are also guiding behavior change (Deci & Ryan, 2008). According to the self-determination theory (2008), individuals are eager to pursue mastery, competence, and completion. Deci and Ryan (2008) claim that individuals tend to take certain actions only because they are enjoyable. Moreover, they argue that reinforcing competency, autonomy, and self-efficiency can help with the behavior change process (Deci & Ryan, 2008).

The Norm Activation Model hypothesizes that anticipated pride and guilt cause individuals to behave in a manner that is compatible with personal norms, which lead to personal feelings, responsibility, and behavior change (Onwezen, Antonides, and Bartels, 2013). According to the Norm Activation Model, personal norms enable individuals to behave environmental-friendly in line with the commonly believed norms about protecting the environment in society. It is because personal norms are social norms internalized at the individual level (Williamson, Satre-Meloy, Velasco, & Green, 2018). Aligning personal norms with descriptive and injunctive norms can permanently change people's behavior (Cialdini, Reno, & Kallgren, 1990; Burgess, 2018). Descriptive norms refer to what is commonly done in the society, while injunctive norms are what behavior that individuals should do (Williamson, Satre-Meloy, Velasco, & Green, 2018). These norms are also effective in changing behavior to tackle anthropogenic climate change since individuals are inclined to be tuned into their social norms that everyone behaves responsible for the environment (Burgess, 2018).

MOTIVATION

UC San Diego Climate Action Plan

In 2005, the former governor of California, Arnold Schwarzenegger, issued the Executive Order S-3-05 establishing statewide targets to reduce greenhouse gas emissions to 80 percent below 1990 levels by 2050 (State of California, 2019). Then years later, Governor Jerry Brown signed Executive Order B-30-15 to establish an interim greenhouse gas

emissions targets at 40 percent below 1990 levels by 2030 to ensure the state will meet its commitments by 2050 (The City of San Diego, 2016). The president of University of California implemented a carbon neutrality initiative to require all UC campuses to achieve carbon neutrality, including emissions from daily commute and university-funded air travel, by 2050 (UC San Diego, 2019). To meet the greenhouse gas reduction targets established by both the state and University of California, UC San Diego developed the first campus Climate Action Plan (CAP) in 2008. The main strategies are listed as follows

- "Reducing GHG emissions to 20 percent below 1990 levels by 2020;
- Achieving climate neutrality in direct and indirect emissions by 2025, and achieving the full carbon neutrality, including emissions from daily commute and university-funded air travel, by 2050;
- "Continuing to certify new and existing building under the LEED rating system; and
- "Improve the energy efficiency of all electric equipment (UC San Diego, 2019, p. 4)."

The 2019 Climate Action Plan (2019 CAP) analyzed the history, current, and projected greenhouse gas emissions of UC San Diego. The documents then embodied the analyzed results with the climate mitigation strategies of the university to meet its commitments. The 2019 CAP provides the inventory of the UC San Diego greenhouse gas emissions in 2016, with the total campus emissions of 270,330 metric tons of carbon dioxide equivalent ($MTCO_2e$) (UC San Diego, 2019). Table 1 provides the detailed 2016 campus emissions according to different scopes and sources. Table 2 indicates the carbon reduction targets in line with the Presidential Carbon Neutrality Initiative. Comparison between projected

emissions without mitigations and the respective reduction commitments for each of the target years are shown in Table 2 (UC San Diego, 2019).

Table 1: 2016 Campus Emissions. Source: University of San Diego, 2019

GHG Emission Scope and Source	$MTCO_2e$	Percentage of Total
Scope 1 – Stationary Combustion	159,607	57.2%
Scope 1 – Mobile Combustion	3,462	1.2%
Scope 1 – Fugitive/ Other Emissions	1,737	0.6%
Scope 2 – Purchased Electricity	35,413	12.8%
Scope 3 - Commuting	61,564	21.9%
Scope 3 – Air Travel	17,547	6.3%
Total	270,330	100.0%

Table 2: Emissions Reduction Targets. Source: University of San Diego, 2019

Year	Total Emissions In Absence of Mitigating Measures ($MTCO_2e$)	UC San Diego Emissions Reduction Targets ($MTCO_2e$)
2020	281,979	166,051
2025	295,889	57,508
2037	348,339	29,904

The 2019 document classified greenhouse gas emissions inventory into three categories as shown in Table 1:

- Scope 1: Direct emissions, including stationary combustion, fugitive emissions, and campus fleet;
- Scope 2: Indirect emissions that results from purchased electricity; and
- Scope 3: students, staff, and faculty commuting and university-funded air travel (UC San Diego, 2019).

From Table 1, it is clear that commuting accounts for approximately 22% of the campus greenhouse gas emissions in 2016. Moreover, among the three categories, greenhouse gas reduction from transportation to and around the campus can be tracked, monitored, and achieved at the individual level.

The purpose of the capstone project is to provide an innovated way to reduce transportation footprint by promoting sustainable commute behavior, including walking, biking, electric scooter sharing, and using mass transit. It is unarguable that the overall success in meeting the campus carbon mitigation commitments is a shared campus responsibility. Therefore, the motivation of this capstone project is to engage each individual in the UC San Diego community in developing a sense of collaboration and in making contributions to reduce personal carbon footprints from daily low-carbon commute behavior, in the hope of achieving the campus carbon reduction targets and tackling anthropogenic climate change.

Using Digital Technologies to Tackle Anthropogenic Climate Change – The Case of Ant Forest

Modern technology and science are available to decarbonize energy sources, industrial manufacture, and transport systems. In the Internet era, digital technologies have been introduced to encourage the public to participate in climate action. In 2016, Ant Forest was launched on Alipay, which is a mobile payment platform controlled by the world's largest retailer and e-commerce company Alibaba (United Nations, 2019c). Ant Forest is an

interactive pro-environmental initiative, using gamified mobile technologies to promote low-carbon lifestyles to tackle climate change (Chen & Cai, 2019). Ant Forest rewards users with "green energy" every time they engage in pro-environmental activities to reduce personal carbon emissions, such as utilizing green transportation modes, going paperless in the office, paying utility bills online, green package ordering, and recycling (Geng, 2018). Users can use the green energy to grow their virtual trees on the app (United Nations, 2019c; Chen & Cai, 2019; Geng, 2018). When the virtual trees grow big enough, real trees will be planted in Northwest China by Ant Financial and their partnered local NGOs (United Nations, 2019c). Each real tree has an ID that represents the pro-environmental efforts made by the corresponding user (Chen & Cai, 2019).

Since the launch of Ant Forest, over 500 million users have joined the green initiative, over 122 million real trees have been planted covering 112,000 hectares of the most arid regions in China, and a total area of 12,000 hectares of conservation land has been protected (United Nations, 2019c; Geng, 2018). According to China's Ministry of Ecology and Environment, trees planted by users of Ant Forest have offset 7.9 million tons of greenhouse gas emissions (Wang, 2019). In September 2019, Ant Forest received the 2019 "Champions of the Earth" award, which is the United Nations' highest environmental honor, for it inspires half a billion people to turn the green good deeds into real trees (United Nations, 2019d). Ant Forest shows that digital technology can be applied to encourage massive individual efforts to combat climate change. Motivated by the success of Ant Forest, Triton Green was designed to inspire individuals in the UC San Diego community to

participate in the UC Presidential Carbon Neutrality Initiative as well as in tackling climate change through engagement in daily low-carbon activities beginning with green commute behavior.

METHODS

Triton Green

Triton Green aims to promoting a sustainable community around the UC San Diego (UCSD) campus. Inspired by Ant Forest, Triton Green is envisioned as a pervasive and ubiquitous platform that combines mobile technology, psychological incentives, cooperative and competitive gamification, and social-media to empower and reward students at UCSD to reduce their carbon footprint from transportation. It links the university's carbon mitigation targets with personal daily commute activities. Through a game-playing experience, users are expected to learn what actions are environmentally friendly as they are rewarded with points, likes, and financial as well as in-kind prizes for opting in pro-environmental commute behaviors. Triton Green also brings social networking into play. From watering friends' virtual plants to giving them carbon points, the collective power of social relationships would be strengthened. Triton Green provides dynamic dashboards that display friend's daily and accumulated carbon points from green travel trips they have taken. Users will have a sense of how much effort they have made in reducing their personal transportation footprint compare with that of their friends. They are expected to be more likely to engage in green commute behavior and further commit to pro-environmental lifestyles while experiencing comparative and competitive interactions with

their friends. More details about the design of Triton Green are discussed in the following sections.

As mentioned previously, the purpose of Triton Green is to engage every student at UC San Diego in daily low-carbon commute behavior, in the hope of achieving the campus carbon reduction targets and tackling anthropogenic climate change. Before developing Trigon Green, a commute behavior survey was conducted to get clear understanding of the current commute habits, climate change attitudes, and motivations of students at UC San Diego for choosing green travel options. Since a greater portion of graduate students live off-campus, they were picked as the survey respondents.

The 2019 Graduate Students Commute Behavior Survey

Survey Design and Distribution

As mentioned above, the purpose of the commute survey was to better understand the commute behavior and habits of graduate students at UC San Diego. We are particularly interested in commuter behaviors related to the use of public transit or whether commuters drive alone, as well as adoption of additional transportation methods such as shared bikes and electric scooters. The survey asked participants about the commute modes they typically take to the UC San Diego campus. Participants were also asked about what they perceived as being beneficial or rewarding about mode, what barriers they had with taking each mode more, and what kind of rewards would motivate them to choose

sustainable modes of transportation more often. Questions about climate change opinions and smartphone usage were also included in the survey. The survey items included both open-ended and closed-ended responses.

The survey included five dividing questions that led participants to different sections based on their answers. For example, Question 19 is a dividing question for respondents who usually drive alone more than once to campus and those who do not. The former group was required to answer a series of questions about riding in a single-occupancy vehicle to campus. Those questions were designed so that information could be collected about why respondents drive in a single-occupancy vehicle to school and what prevents them from taking more sustainable commute modes.

Every question in the survey required a response with exception of the last item, which provided respondents with the opportunity to voluntarily enter their email address to get an Amazon eGift card as a "thank you" for their participation. Amazon eGifts were awarded to the first 100 participants who completed the survey according to the time order. Each of the first ten participants got a $25.00 Amazon eGift card, participants 11 through 30 got a $15 Amazon eGift card, participants 31 through 60 got a $10 Amazon eGift card, and a $5 Amazon eGift card was awarded to the remaining 39 participants in the survey. The gift cards were distributed via emails.

The commute behavior survey was conducted online. It followed the design of web-based survey methods that support multiple platforms and browsers in both smartphones and computers, present questions logically and adaptively, express thank-you upon completion of the survey, and prevent numerous submissions automatically. The survey was mainly distributed through social media, including the official accounts of UCSD Graduate Life Twitter and Instagram, as an anonymous link. In this case, sampling bias occurs, and the results skew to graduate students who may be more connected with campus activities. The survey was administered online for two weeks, which was from October 28 to November 8. The average response time was 10 minutes. One hundred and sixty-three graduate students completed the survey.

The survey provided both quantitative and qualitative data on both commute to campus as well as intra-campus commute behavior. Results from the commuting survey are mainly used to design Triton Green; however, they can also be used as supportive information for UCSD transportation planning and management in the future. The questionnaire used for the survey is in Appendix A.

Key Findings

Most respondents use sustainable modes of transportation when traveling to the UCSD campus.

- The majority (80%) of the respondents usually take sustainable transportation modes to commute to or from campus. i.e., walk (15%), bike/e-scooter (10%), public transit (26%), campus shuttle (20%), and ridesharing services (9%).

Traveling between different locations on campus is common for respondents during a typical workday.

- Most respondents typically choose the sustainable mode of transportation when moving around campus, including walking (87%) and campus shuttle (25%).
- However, taking public transit (7%), riding shared bikes or e-Scooters (8%), and using ridesharing services (2%) are less popular intra-campus-travel choices.

Respondents are taking public transit to the UCSD campus.

- Seventy-seven of the respondents have taken regional buses and trolleys to get to work or class. Of those, 86% participate in the MTS - U pass program. 85% usually show the driver a pass displayed on their smartphones when boarding.
- Forty-five percent of respondents indicate that public transportation benefited them financially.
- A quarter of the respondents find taking public transit is more convenient than driving alone during workdays.
- One in five respondents choose public transit to reduce their carbon footprints.

- Respondents would be more willing to travel with regional buses and trolleys if there were more availability in bus routes and express buses from their home to work or class, more affordable graduate student housing provided near the university, and less parking spots on campus.

Long commute distance and time are primary barriers that keep respondents from taking buses and trolleys more often to campus. Some respondents indicate that they are willing to switch to public transit if express buses were provided, and new bus routes were planned. Such infrastructure barriers make it difficult for Triton Green to change commute behaviors.

- Forty-three percent of respondents indicated that they drive single-occupancy vehicles (SOV) more than once per month to campus.
- Respondents who live more than 7.5 miles from university prefer SOV during a typical weekday more often than those who live closer to campus. However, 59% of respondents who usually drive alone live within a five-mile radius of the UC San Diego campus
- Distance, length of ride, and cost are the primary factors that prevent respondents from switching to walking, public transit, and ridesharing services, respectively.
- High cost of parking permits, limited parking spaces on campus, and concerns about the environment would discourage them from using a single-occupancy vehicle to get to work or class.

Shared bikes and electric scooters are not popular among respondents as only 28% of them have ever ridden a shared bike or e-Scooter around the UCSD campus.

- Cost, personal safety, lack of motivation, no bike lane, and the need to return shared bikes (or e-Scooters) to campus on the same day are the main reasons why respondents dislike shared bikes and e-Scooters.

Respondents may be willing to switch to a more sustainable way to commute with the right incentives.

- Financial prizes, such as student discounts and free rides, are the best motivators for all respondents to use sustainable modes of transportation, followed by in-kind prizes, like real samplings.

Most respondents believe in anthropogenic climate change, and they are willing to engage more in combating climate change.

- Three in five respondents agree that an individual's daily low-carbon activities would benefit the environment.
- 72% of respondents think tracking their personal carbon footprint could help them to reduce daily greenhouse gas emissions.
- 63% of respondents are willing to drive a single-occupancy vehicle to campus less if they are offered a reasonable commute alternative.

Only a few (30%) of respondents have ever used the UC San Diego mobile app on their smartphones.

- Eighty-five *percent of respondents* show the driver a pass displayed on their smartphones when boarding.

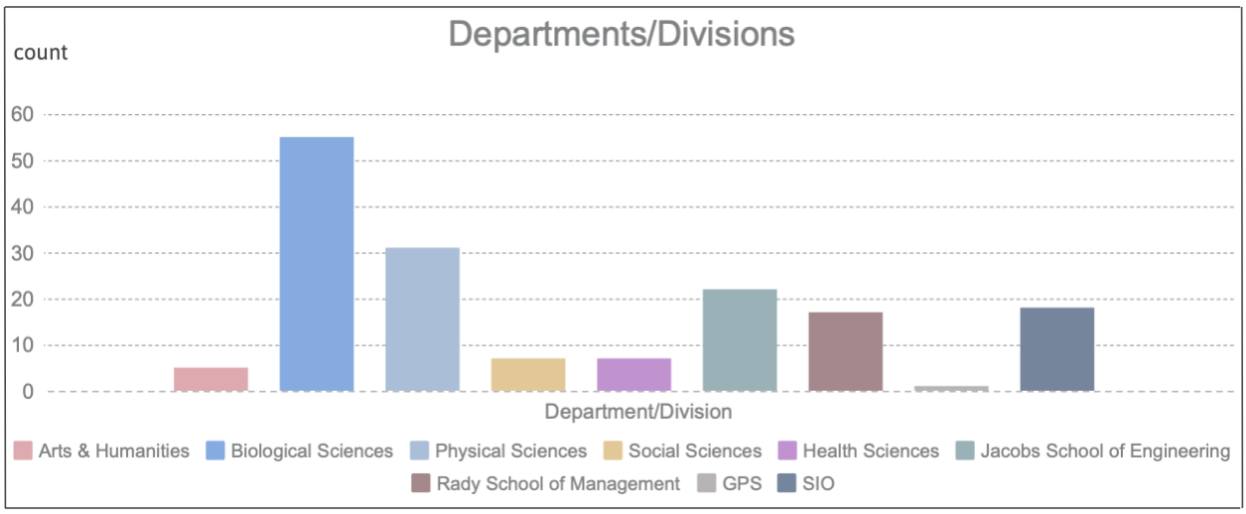
- Thirty-eight percent of respondents regularly use health and fitness apps to track their daily steps. Among them, more than half of respondents usually make five to ten thousand steps a day
- Social networking (83%) music (82%), and game (33%) are popular types of mobile applications among respondents.

Survey Results

Demographic Information

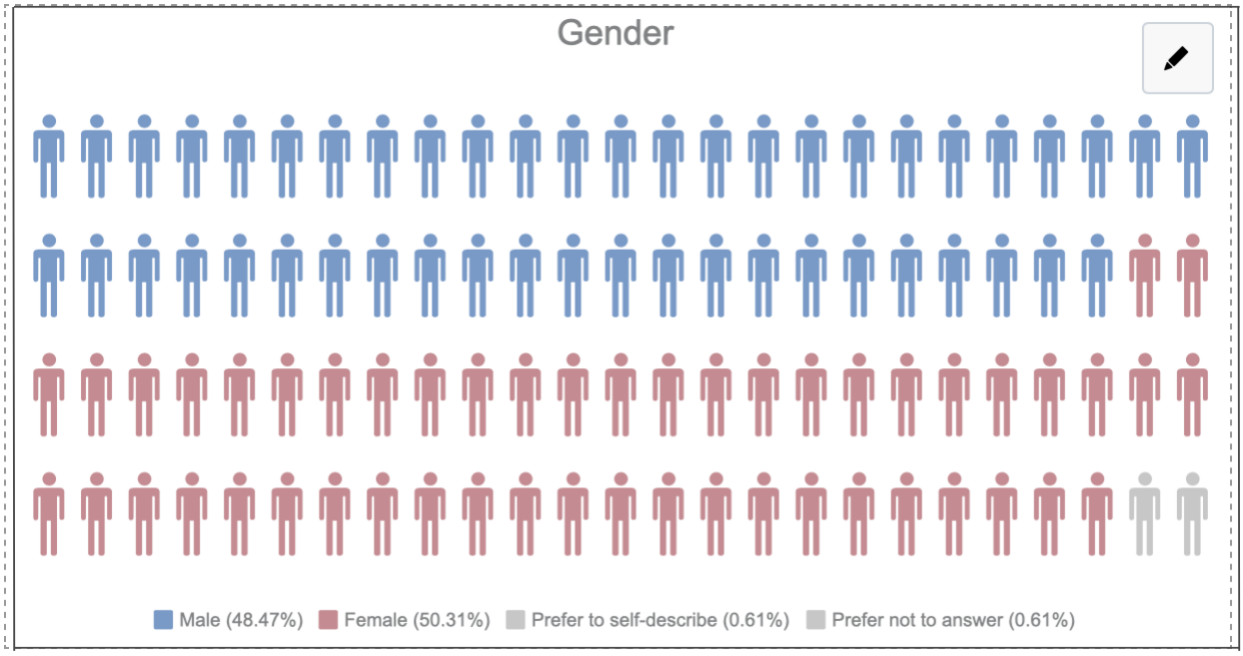
A sample of 168 responses was collected. To correct for the unequal probabilities of selection, sample weight, which is the reciprocal of the probability of the selection into the sample, is constructed (Yansaneh, 2003). In the 2019-2020 fall quarter, there are 8839 graduate students enrolled in UCSD (UC San Diego, 2019). Thus, the sample weight is 53, which means that a sampled graduate student represents 53 graduate students in the population of UC San Diego.

Chart 1: Departments/Divisions Distribution



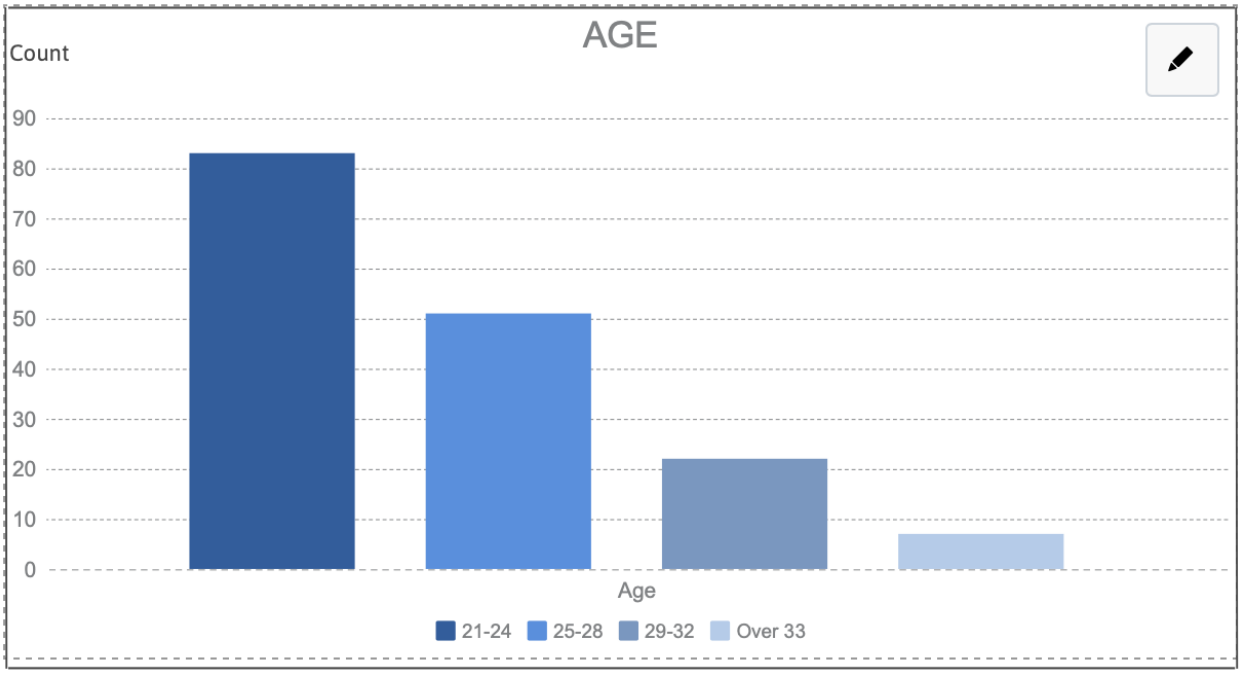
Since the survey was mainly conducted via social media, five responses that came from undergraduate students and post-doctors at UC San Diego are included in the raw data. However, those five responses were dropped when analyzing the survey result because the objects of the survey are only graduate students. The results of the survey were also skewed to graduate students who major in STEM (science, technology, engineering, and mathematics) programs. Chart 1 gives the distribution of survey responses according to different departments and divisions.

Chart 2: Gender Distribution



As indicated in *Chart 2*, 50.31% of the respondents are females, while 48.37% of the respondents are males. The rest of the respondents preferred either not to reveal their gender or to self- describe. Almost half of the respondents are from the age of 21 to 24, and the vast majority are under the age of 28 (shown in Chart 3). Among the 163 respondents, 53% of them are in Ph.D. programs while the rest are in master's programs.

Chart 3: Age Distribution



Baseline Trips

Survey results from the question of "In a typical week, please check the mode that you most often use to travel to/from the UCSD campus," were totaled across nine different commute modes and summarized into the commute trips table provided below. To calculate the total estimated trips to campus by the total population of UCSD graduate students, the number of 8839 UCSD graduate students was multiplied by five, which is the number of average commute workdays respondents travel to campus in a week. The results equaled 44,195 estimated total trips taken by all graduate students at UCSD per week.

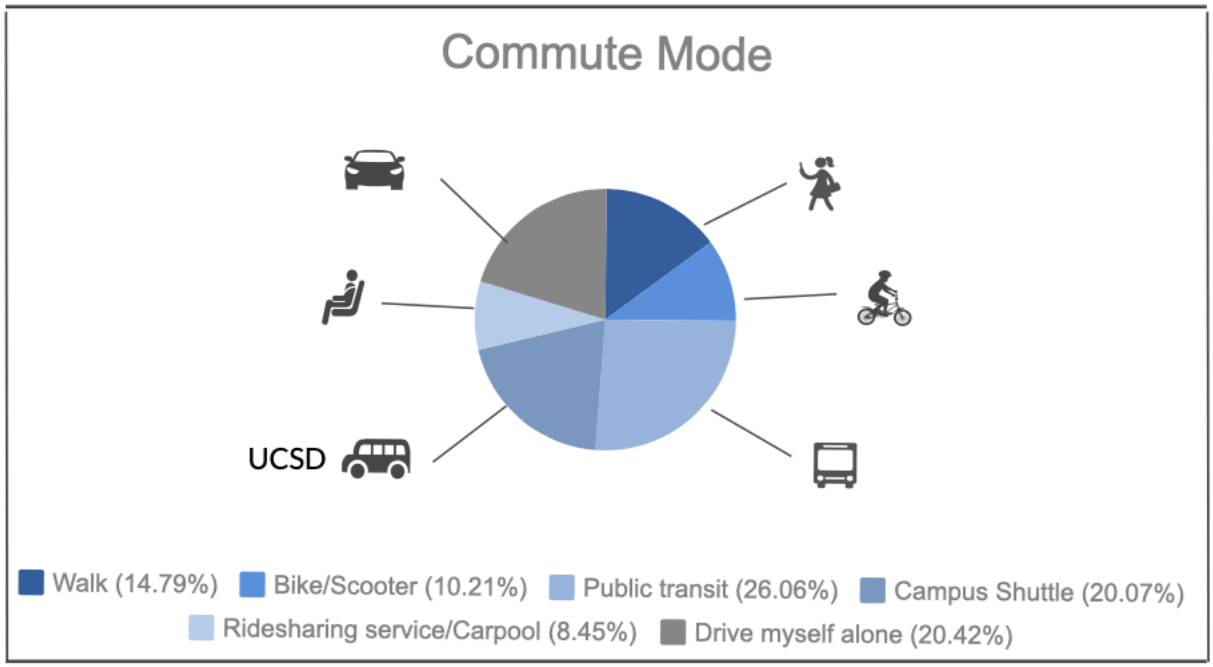
Table 4: Baseline Trips

Commute mode	Trips taken by sample population	÷	Total trips taken by sample population	=	Proportion of trips by mode	X	Total number of graduate students at UCSD x five days	=	Estimated trips by total UCSD graduate students
Walk	42	÷	284	=	15%	X	44,195	=	6629.25
Drive myself alone	58	÷		=	20%	X		=	8839
Bike/ Scooter WITH OUT public transit	21	÷		=	7%	X		=	3093.65
Bike/ Scooter WITH public transit	8	÷		=	3%	X		=	1325.85
Public transit	74	÷		=	26%	X		=	11490.7
Carpool/ Vanpool /On-demand ride-sharing service	24	÷		=	9%	X		=	3977.55
Campus shuttle	57	÷		=	20%	X		=	8839
Total	284	÷		=	100%	x		=	44,195

Commute Mode Split

The survey shows that most graduate students at UC San Diego have developed sustainable travel behavior. According to the survey results, the majority (80%) of respondents typically use sustainable commute modes, including walking (15%), riding a bike or a scooter (10%), public transit (26%), campus shuttle (20%), and ridesharing service (9%), to get to work or class on campus. While 20% of respondents usually drive themselves alone to the UCSD campus (as shown in Chart 4).

Chart 4: Commute Mode Split



Commute Miles and Time

The charts in this section provide information about commute miles, time, and corresponding commute preferences among survey respondents. Chart 5 shows that 76% of respondents live within a five-mile radius of UC San Diego campus, while the rest live more than 5 miles away. The chart also displays that most respondents (77%) spend less than 30 minutes on a one-way trip to campus.

Chart 5: Commute Miles and Time Split

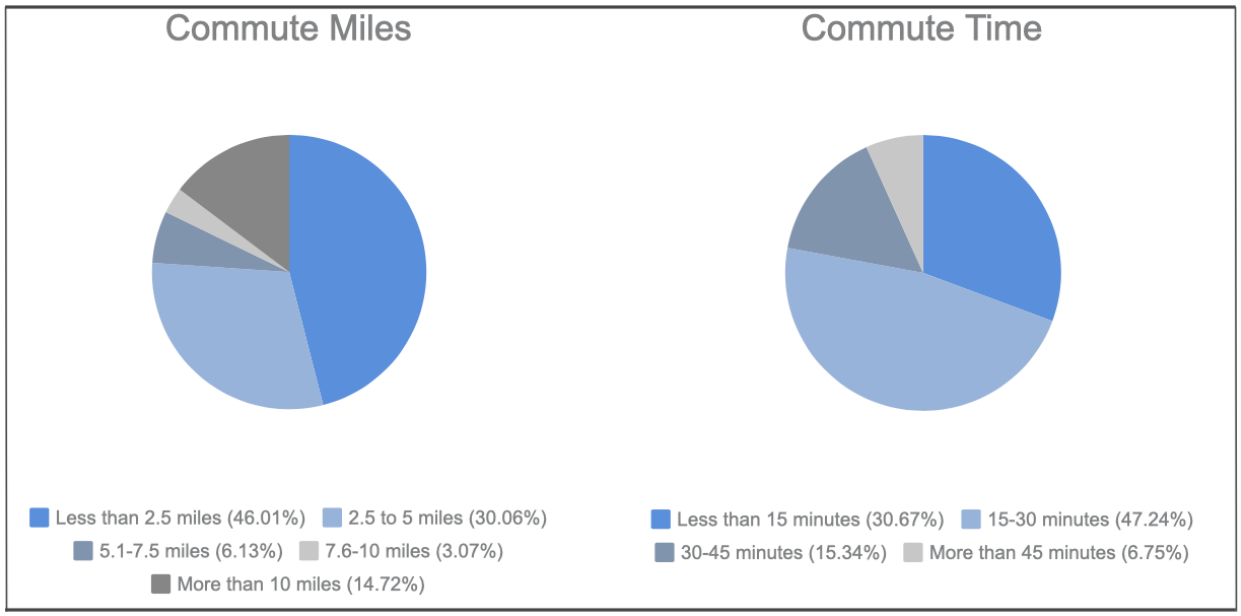
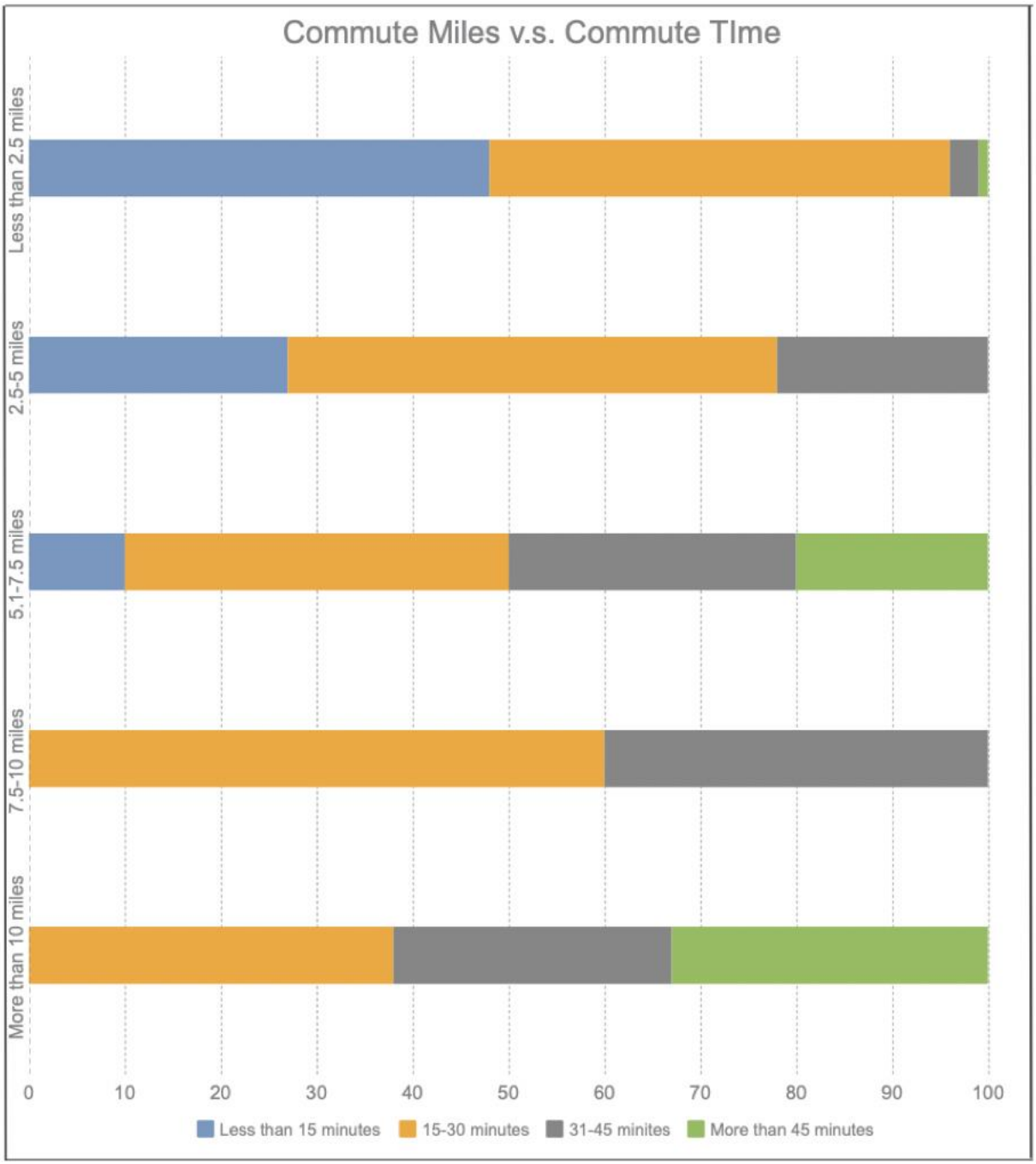


Chart 6 indicates a detailed relationship between commute miles and commute time. It is important because respondents who live closer would be more likely to choose sustainable travel methods for work or class than those who live farther. The latter group would have less access to green travel options, and they would waste too much time in transit if they did not commute by car.

Chart 6: Commute Miles vs Commute Time

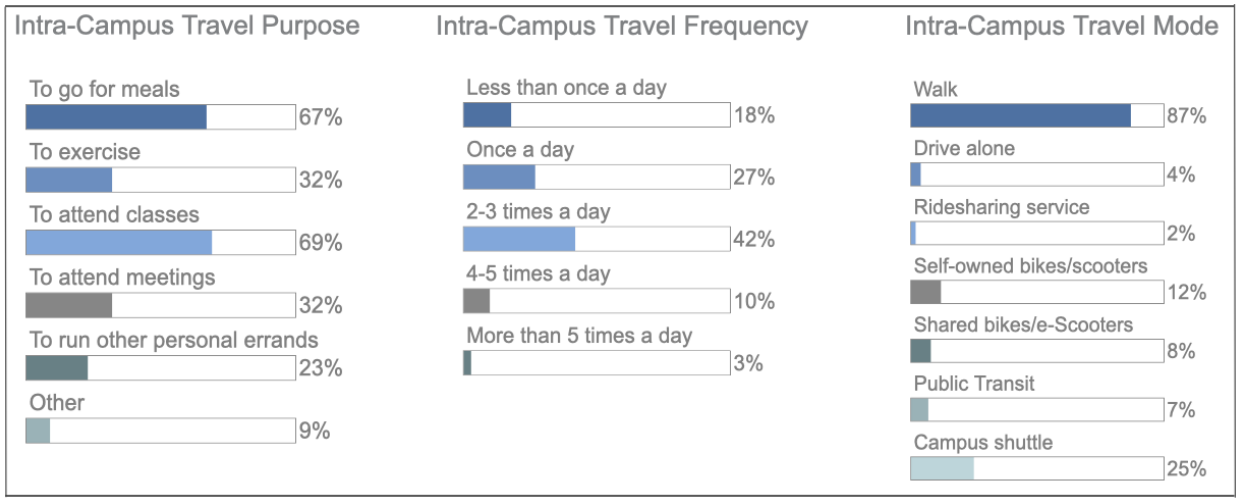


Intra-Campus Travel

The 2019 commute behavior survey asked graduate students about how frequently they travel from one on-campus destination to another on-campus destination in a typical day, what their primary travel purpose is, and what primary modes of transportation they use. Respondents were allowed to choose more than one travel purpose as well as travel mode.

As shown in Chart 7, traveling among different locations on campus is common for respondents during a typical workday. More than half of the respondents claimed that they move among campus points more than twice per day, while only 18% of the respondents seldom take any intra-campus trip. Traveling around campus for meals (67%) and classes (69%) are primary travel purposes for respondents. Almost one-third of respondents indicate that they travel between campus sites to go for exercise or to attend school-related meetings, respectively.

Chart 7: Intra Campus Travel Purpose, Frequency, and Mode

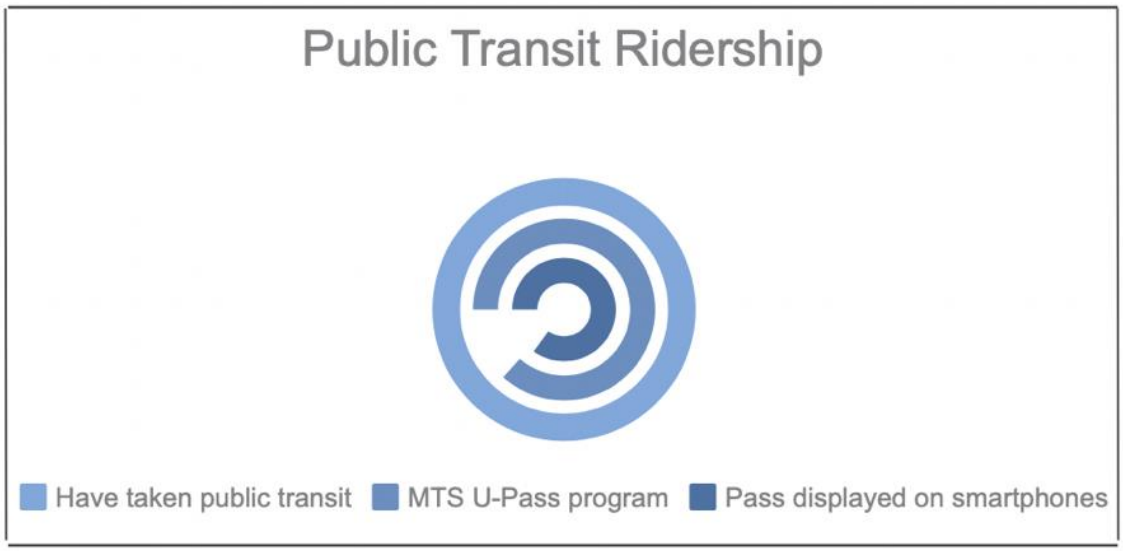


Walking is the most common commute mode that respondents use when traveling from one campus destination to another. A quarter of respondents indicate that they ride with campus shuttles when moving among different UCSD campuses. However, taking public transit (7%), riding shared bikes or e-Scooters (8%), and using ridesharing services (2%) are less popular commute choices, and so is driving alone (4%).

Travel by Public Transit

The 2019 commute survey asked graduate students at UCSD to indicate their opinions about taking public transit to campus. Public transportation enjoys a high ridership rate; 126 respondents (77%) have taken MTS buses and trolleys as well as NCTD Breeze buses to get to work or class. Of those, 109 respondents indicate that they participated in the MTS - U pass program, and 107 respondents point out that they usually show the driver a pass on their smartphones when boarding on buses (as shown in Chart 8).

Chart 8: Public Transit Ridership



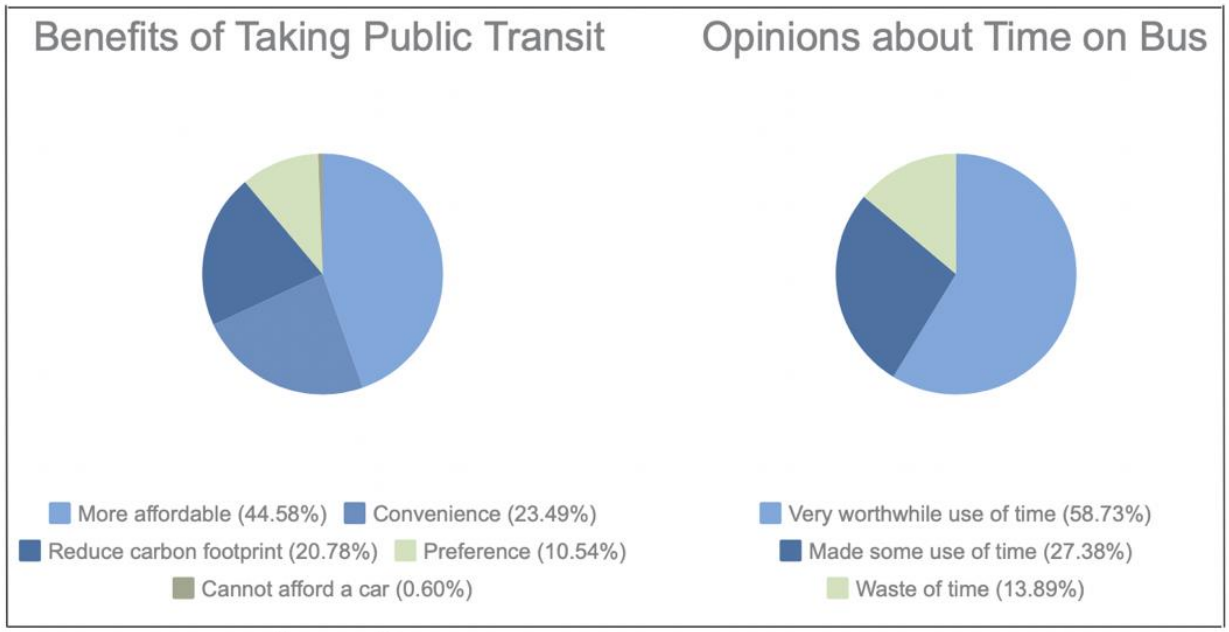
When taking public transit to campus, 63% of respondents never transfer between buses or trolleys on a one-way trip to campus. By contrast, 12% of respondents have to change buses at least twice per trip, and a quarter transfer on another bus at least once per trip.

The 2019 commute survey data also show that one in five respondents tend to ride a bike or an e-scooter to a bus stop, while the rest usually walk instead. Moreover, 84% of respondents indicate that they prefer to walk no more than one mile to a bus stop, including the farthest distance to walk for a quarter-mile (24%) and a half-mile (32%).

Chart 9 below provides general opinions about how respondents who have taken public transit to campus think about this commute mode. Forty-five percent of respondents indicate that public transportation benefited them financially. Twenty-four percent of them find taking public transit is more convenient than driving alone during workdays. Twenty-one percent choose public transportation to reduce their carbon footprint. Ten percent prefer public transit rather than other commute modes to get to work or class, and the rest tend to ride on regional buses and trolleys because they could not afford a car. When asked about how they view the time spent on a bus/trolley during a one-way trip to campus, 86% of respondents indicate that they at least use some of their time to accomplish things, but the rest treat taking public transit to university as a waste of time.

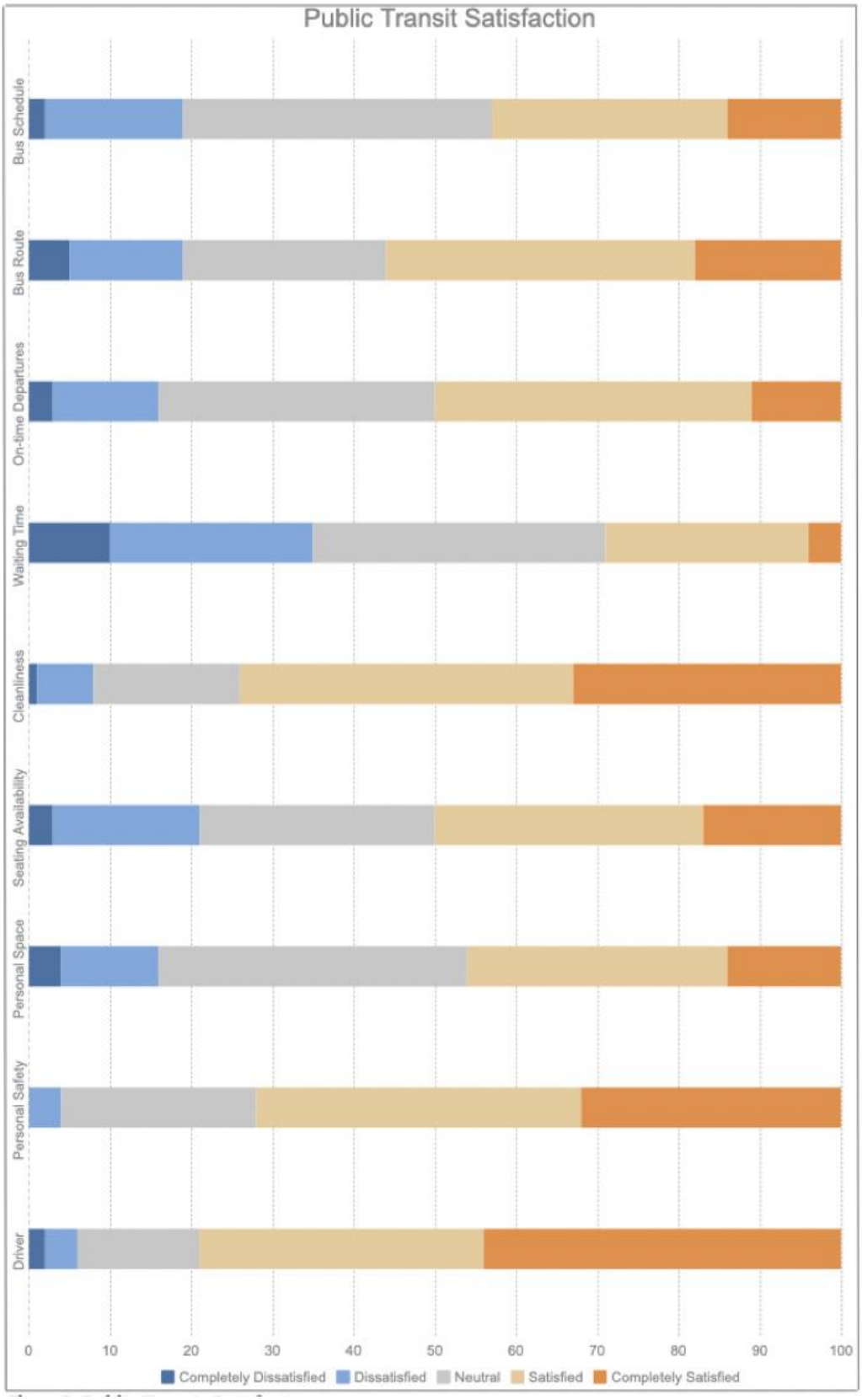
Chart 9: Opinions About Public Transit

(For respondents who have taken public transit to campus)



The 2019 commute survey also asked respondents to indicate how satisfied they were with public transit to the UCSD campus. Chart 10 below shows that satisfaction varies based on various factors on the bus. As shown in Chart 10, respondents who have taken public transit to campus indicate high satisfaction with the bus driver (79% at least "satisfied"), cleanliness and condition inside the bus (74%), and personal safety (72%). Respondents are also somewhat satisfied with the ability to find a seat or standing space on the bus (50% at least "satisfied"), bus routes (56%), and on-time departures (50%). Respondents are less satisfied with the bus schedule (43%) and personal space on the bus (46%). On the contrary, they are unhappy about the wait time at a bus stop (35% at least dissatisfied).

Chart 10: Public Transit Satisfaction



In the 2019 commute survey, all respondents were also asked whether various incentives would change their commute mode choices. Chart 11 indicates the percentage of respondents who were willing to take public transit more often to campus based on different incentives. The top three incentives to motivate respondents to take public transportation regularly include receiving financial prizes to save money, reducing personal carbon footprint, and winning in-kind awards, such as real sapling. Respondents also indicated that they would be more willing to travel with regional buses and trolleys to campus if there was more availability in bus routes and express buses from their home to work or class, more affordable graduate student housing provided near the university, and less parking spots on campus.

Chart 11: Incentives to Take Public Transit More Often

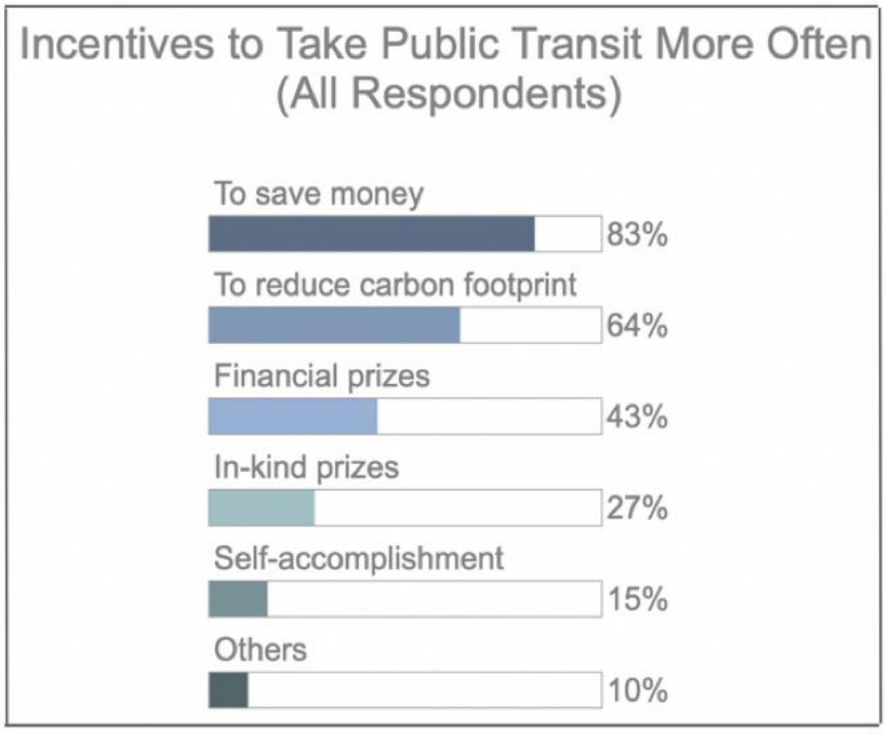


Table 5 shows whether respondents who live in different commute distances, have taken public transit or not. According to the table, around 20% of respondents who live within five miles from campus never travel with public transit. On the contrary, 67% of respondents who live more than five miles away from campus indicate that they have ridden a bus or trolley to get to work or class. We are interested in what prevents graduate students who live closer (within five miles) to campus from taking public transit and what would motivate them to switch to green travel modes. More details are discussed in the "driving alone" section.

Table 5: Whether Respondents Have Taken Public Transit to Campus or Not

Have you ever taken public transit to/from/around the UCSD campus? When answer "Yes" is selected.						
Commute Distance	**Less than 2.5 miles**	**2.5 – 5 miles**	**5.1-7.5 miles**	**7.6-10 miles**	**More than 10 miles**	**Total**
Count	63	37	9	3	14	126
Have you ever taken public transit to/from/around the UCSD campus? When answer "No" is selected.						
Count	12	12	1	2	10	37
Total	75	49	10	5	24	163

Travel by Driving Myself Alone

Forty-three percent of respondents indicated that they drive single-occupancy vehicles (SOV) more than once per month to campus. Correspondingly, 70 out of 163 respondents went on the "driving myself alone" part of the survey to get a better understanding of their

incentives to commute by SOV to campus, and obstacles that prevent them from taking sustainable modes of transportation.

According to survey results, the top three reasons respondents drive alone to campus are no reasonable transit options near the living area (47%), irregular hours on campus (54%), and long commute time by any other commute mode (53%). On the country, parking does not bother respondents too much. When driving alone to campus, a majority of respondents usually park in a parking lot or garage on campus, a quarter choose free street parking, and the rest prefer either metered street parking or a public parking lot off-campus. The average monthly parking charge is 40 US dollars for respondents who regularly commute by SOV to get to work or class

The 2019 commute survey also asked respondents who regularly drive alone to campus about what they see as barriers for taking other modes of transportation. Table 6 provides the top three obstacles for taking a more sustainable commute mode to get to work or class.

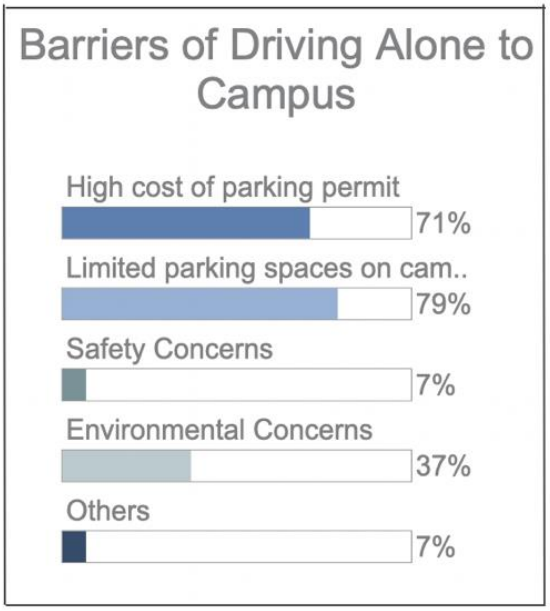
Table 6: Barriers of Walking, Taking Public Transit, and Using Rideshare Services

Barriers of walking to campus		Barriers of taking public transit to campus		Barriers of using rideshare services (i.e. Lyft) to campus	
Distance	71%	Length of Ride	66%	Cost	83%
Time	63%	Distant to a Bus Stop	50%	Lack Motivation	24%
Personal Safety	16%	Long Waiting Time	46%	Personal Safety	11%

As expected, the biggest obstacle with walking to campus is the long commute distance, as more than half of the respondents live more than 2.5 miles from the campus. Likewise, the length of the ride is the most significant factor that prevents respondents from taking public transit to campus. As analyzed previously, a majority of respondents are unwilling to walk for more than a half-mile to take a bus. Accordingly, the long distance to a bus stop is another barrier in using public transportation. Cost is the biggest concern for respondents who choose to use a ridesharing service to campus. When asked to select an alternative mode of transportation instead of driving alone to campus, 37% of respondents indicate that they are willing to use a ridesharing service (i.e., Lyft). 37% prefer public transit, 17% tend to ride a bike or e-scooter, and 9% are more likely to walk to campus instead.

The top two reasons to discourage all respondents from driving alone to campus are limited parking spaces on campus (79%) and high cost of parking permits (71%). Moreover, 37% of respondents indicate that they would use a single-occupancy car less due to environmental concerns (as shown in Chart 12).

Chart 12: Barriers of Driving Alone to Campus



As shown in Table 7, respondents who live more than 7.5 miles from the university prefer SOV during a typical weekday more often than those who live closer to campus. By contrast, respondents who live within 7.5 miles from campus tend to travel with eco-friendly modes of transportation. However, Table 6 also indicates that more than half (59%) of respondents, who usually drive alone, live within a five-mile radius of the UC San Diego campus (referred those respondents as "the Group" in the following discussions). Triton Green aims to change commute behavior of commuters who live relatively close to campus but prefer SOV rather than public transit and other sustainable modes of transport. Thus, we are interested in finding out the reasons for the group to drive alone to campus, what barriers they have with taking public transport, and what would discourage them to travel by SOV and switch to a greener commute behavior instead.

Table 7: Whether Respondents Drive Alone to Campus or Not

Do you usually drive more than once per month to the UCSD campus? When answer "Yes" is selected.						
Commute Distance	**Less than 2.5 miles**	**2.5 – 5 miles**	**5.1-7.5 miles**	**7.6-10 miles**	**More than 10 miles**	**Total**
Count	14	27	3	5	21	70
Do you usually drive more than once per month to the UCSD campus? When answer "No" is selected.						
Count	61	22	7	0	3	93
Total	75	49	10	5	24	163

In result, irregular hours on campus is the primary obstacle for respondents in the Group to commute by green transit (54%). Forty-six percent of them indicate that they commute by SOV to campus because they prefer to use their own car. The same percentage of respondents claimed that driving alone reduced their commute time. Forty-one percent of respondents stated that they drove alone to campus because they needed to run personal errands before or after school. Thirty-four percent of respondents complained about the lack of reasonable transit options near where they live. Limited parking spaces (83%) and higher cost of parking permits (80%) could discourage respondents in the Group to commute by SOV. However, less than a quarter (24%) of them would be willing to switch to green commute behavior only for environmental concerns.

Table 8 provides barriers respondents in the Group indicated in taking public transit to campus. Distance to a bus stop is the primary obstacle that prevents respondents in the

Group from taking public transit, as 48% of them were unwilling to walk more than 1 mile to catch a bus. The length of the ride and long-waiting period at a bus stop are also critical factors that prevent respondents from riding a bus to campus. Furthermore, full buses and wrong real-time information discourages respondents in the Group from taking public transit more often.

Table 8: Barriers Taking Public Transit to Campus

Barriers of taking public transit to campus	Count	Percentage	Total
Cost	5	12%	41
Personal safety	1	2.5%	
Length of ride	20	49%	
Distance to a bus stop	23	56%	
Delayed on board due to traffic	18	44%	
Experienced long wait at the bus stop	20	49%	
Missed departure due to wrong real-time information	15	37%	
Unable to board or denied boarding due to crowding	10	23%	
Have no motivation to take a bus to campus	6	15%	

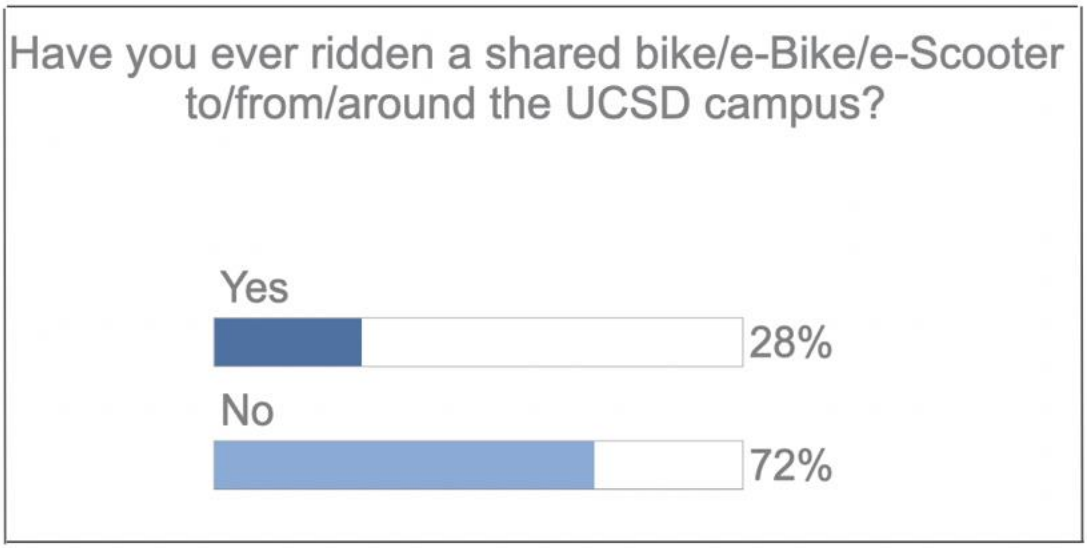
When asked to choose a commute alternative other than driving alone to campus, 32% of respondents in the Group were likely to ride a bike to campus, 29% of them were willing to take public transit, and 25% tended to take a ride-share service instead.

Travel by Shared Bikes/ Electric-Scooters

In 2017, UCSD worked with Spin and launched a bike-share partnership pilot program as a part of a university-wide initiative to become carbon neutral by 2025 (Piercey, 2018). Accordingly, new survey questions about shared bikes and e-Scooters were added in the 2019 commute survey.

Chart 13 indicates that only 28% of the respondents have ever ridden a shared bike or e-Scooters around the UCSD campus. Of those, 78% of respondents point out that shared bikes or electric scooters (e-Scooters) saved time traveling to work or class. 73% indicate that riding a shared bike or an e-scooter was convenient when moving from one campus location to another. 44% find shared bikes and e-scooters to be environmentally friendly compared to other modes of transportation.

Chart 13: Shared Bikes/ E-Scooters Ridership



As shown in Table 9, the top five barriers that prevent respondents from using shared bikes and e-scooters are cost (58%), personal safety (40%), inconvenience (32%, if riders take a shared bike or an e-scooter off campus, they have to return it in a timely manner to campus the same day), lack of motivation (23%), and no bike lane (20%). Moreover, three in four of the respondents indicate that they are likely to try shared bikes and e-scooters if they are offered financial prizes, such as a discount on each ride, compared to 25% of the respondents who would be motivated by in-kind prizes like saplings.

Table 9: Benefits and Barriers of Riding a Shared Bikes or an E-Scooter

Benefits of riding a shared bike/ e-Scooter			**Barriers of riding a shared bike/ e-Scooter**		
Benefits	Count	Percentage	Barriers	Count	Percentage
Time savings	35	78%	Cost	95	58%
Convenience	33	73%	Personal Safety	65	40%
Environmental-friendly	20	44%	Inconvenience	52	32%
Cheap travel costs	20	44%	Lack motivation	37	23%
For health & Fitness	10	22%	No bike lane	32	20%

Change Opinions

In addition to transportation behavior, respondents were also asked about their climate change opinions. As shown in Chart 14, most respondents (83%) think climate change is happening. It is possible that the percentage of respondents who believe in climate change may even be higher, since the statement was worded as, “Climate Change is Not happening” and the respondents may have chosen “Strongly Agree” by mistake. A majority of them (81%) believe the current climate change is caused mostly by human activities. 82% of

respondents are worried about climate change. Three in four respondents think protecting the environment is more important than economic growth. Three-fifths of respondents agree that an individual's daily pro-environmental activities would benefit the environment, and 67% doubt they have engaged enough in combating climate change.

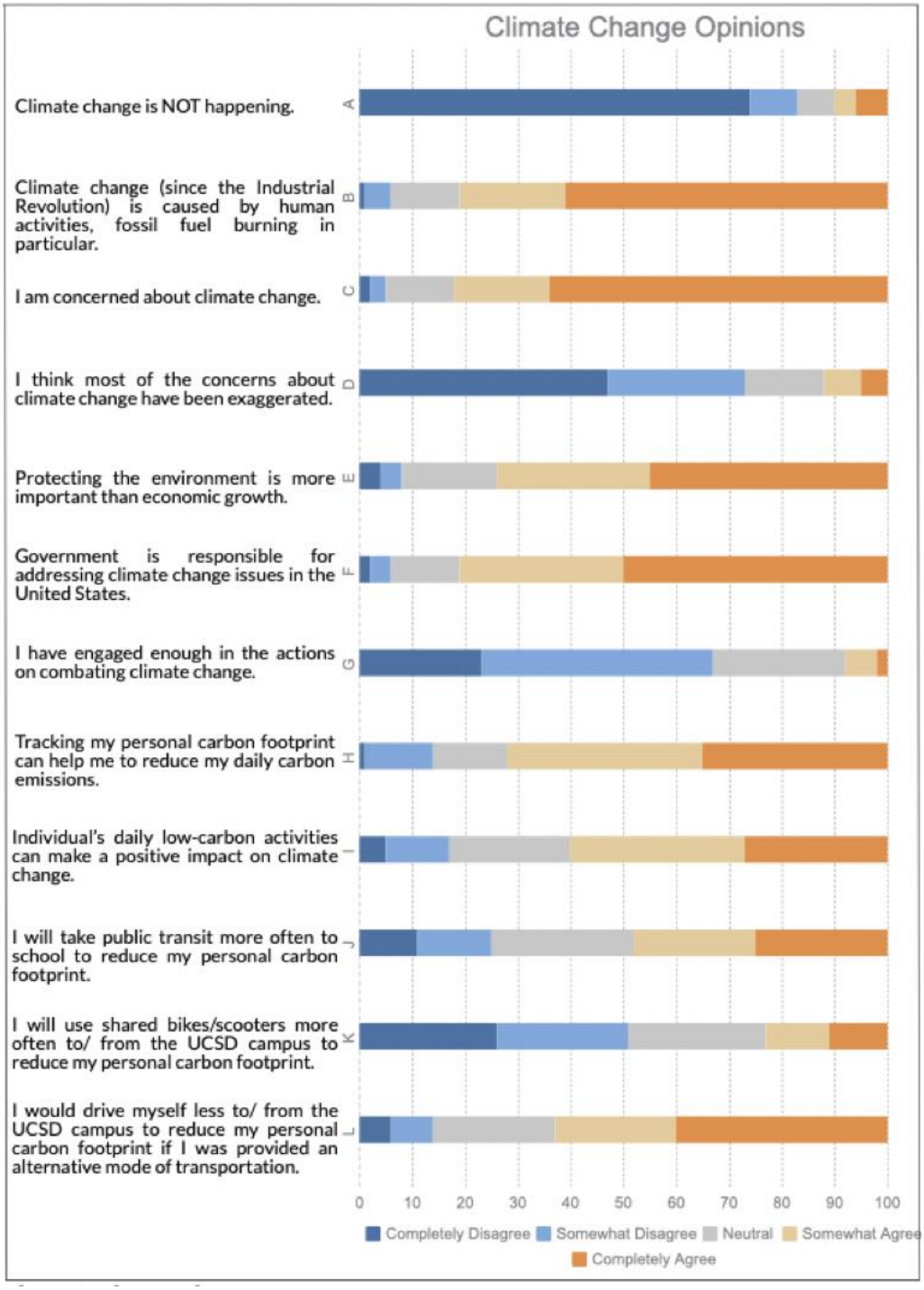
As for personal climate change actions, 72% of respondents hold the belief that tracking their own carbon footprints could help them to reduce daily greenhouse gas emissions. 63% claim that they would drive a single-occupancy vehicle less to campus if they were provided with a reasonable commute alternative. However, less than half (48%) of respondents prefer to take public transit instead of driving alone to reduce their carbon footprint, and 51% of respondents are unwilling to switch to shared bikes or e-scooters.

Smart Phone Usage

Since Triton Green will be an app-like service that is based on the UC San Diego mobile app, several questions were asked to gather information about smartphone usage among respondents. The survey results show a low frequency of the utilization of the UC San Diego mobile app, with 70% of respondents either rarely (48%) or never (40%) using the app. For respondents, the most popular mobile apps choices are social networking (83%) and music (82%). One in three respondents prefers to play games on their smartphone to release pressure from schoolwork. Additionally, 38% of respondents regularly use health and fitness apps to track their daily steps. Of those, more than half of the respondents

usually take five to ten thousand steps a day; the rest walk for less than 5,000 steps (16%) or more than 10,000 steps (29%), respectively.

Chart 14: Climate Change Opinions



App Design

Triton Green is envisioned as a platform that hosted on a smartphone supporting application, the UC San Diego mobile app, which is a location-based mobile app that connects students to campus information. Every student will be granted a Triton Green account when they enter UCSD.

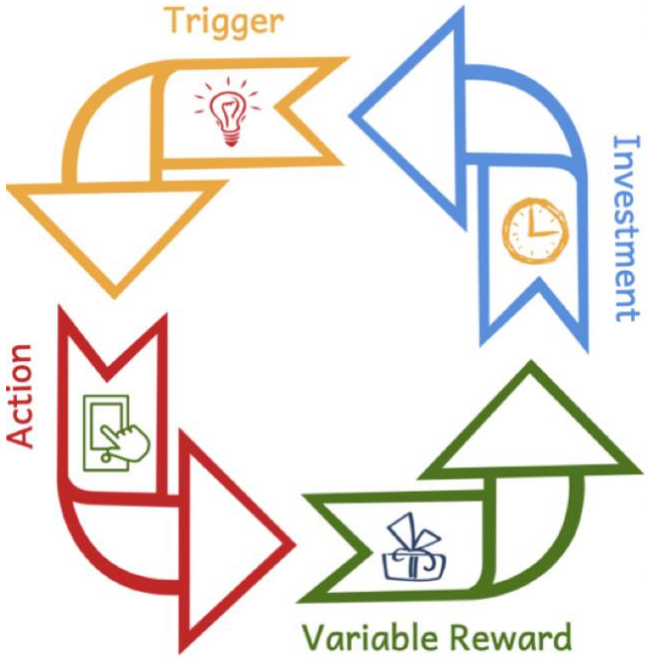
Since the current UC San Diego mobile app is a pure standalone application, some improvements need to be made. For example, the UC San Diego mobile app needs to be upgraded to a social app. Only in this way can users add friends, who are also UCSD students, to their Triton Green accounts. The new mobile social app will enable users to communicate with their friends by visiting their friend's Triton Green home page, collecting carbon points from their friends, and sending out "likes" to support low-carbon activities their friends have made. More details about the social-networking feature of Triton Green will be discussed below.

Trion Green consists of four modules that link the tracking of personal transportation emissions saved from green travel behavior, social media, incentives, gamification, education, as well as fitness and health. Triton Green is also a behavior-forming product, as it is conceived as a continuous process of self-learning and self-improvement. Users would increase their dependency on Triton Green by storing the value of environmental protection after committing to pro-environmental commute behavior.

The Hooked Model

At the present stage, Triton Green is a conceptual product. The blueprint of the platform is based on the results of the commute behavior survey, general concepts of sociology and psychology, and gamification design. The Hooked Model, developed by Nir Eyal (2014), provides the framework for building Triton Green. The hook cycle is comprised of four steps: trigger, action, variable reward, and investment (Eyal, 2014). Figure 1 depicts the four-phase circle to cultivate habits.

Figure 1: The Hooked Model



Similar to most habit formation models, the Hooked Model starts with triggers, which are the foundation of persistent behavior change. Triggers contain two parts: internal triggers and external triggers, both of which cue users to perform a target behavior (Eyal, 2014).

Taking actions is the second stage in the Hooked Model. A desired action has to be as simple, delightful, and streamlined as possible. This is because reducing the conscious and physical efforts to achieve a goal increases the likelihood to take action (Eyal, 2014). The third step to form behavior is providing variable rewards. After taking specific actions, users need to receive a prize to build loyalty, and the diversity of rewards is critical (Eyal, 2014). Eyal (2014) argues that with limited types of rewards that users can anticipate, a product can be quickly abandoned by its users. The last phase of the Hooked Model is investment, which is critical for building a habit-forming product. The more users invest effort and time into a habit-forming product, the more likely behavior change will happen (Eyal, 2014).

Trigger

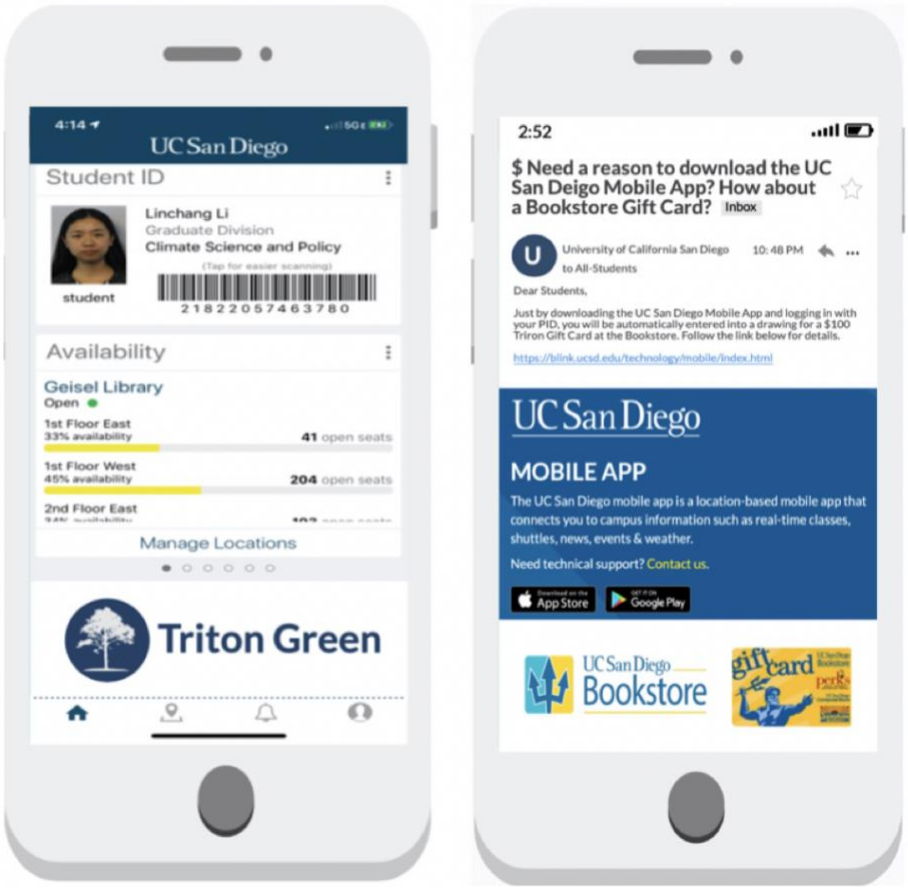
External Triggers

Triggers, driven by either external or internal cues, offer the basis for continuous behavior change (Eyal, 2014). External triggers, such as owned triggers and relationship triggers, convey information, and inform users about what to perform next.

Owned triggers build up repeat engagement until habits are formed (Eyal, 2014). Such triggers are only set after users activate their Triton Green accounts manually, even though they were already provided with an account when they enrolled at UCSD. Otherwise, it is impossible to change users' behavior without permission to enter their attentional space (Eyal, 2014). To activate the Triton Green account, students need to download the UC San

Diego mobile app, log in to the mobile app with their student ID (PID), and tap the Triton Green logo. As shown in Figure 2, the Triton Green logo serves as an external trigger that prompts students to take actions as well. However, the commute behavior survey shows that more than half (70%) of the respondents rarely or never use the UC San Diego mobile app. Therefore, prominent buttons, such as “Download on the App Store” and “Get it on Google Play,” could provide explicit instructions about what action to take after reading the email, which prompts students to download the application first. Triton Green gives students reasons to utilize the UC San Diego mobile app.

Figure 2: External Triggers



Relationship triggers will also be applied to build an engaged user base and strengthen the user loyalty of Triton Green. A myriad of successful internet services, such as Facebook, demonstrate that there is no better advertisement than word of mouth exposure in technology diffusion (Eyal, 2014). The marketers refer to the business strategy that spreads product information from person to person via the internet as “viral marketing” (Kagan, 2018). However, the general public knows it by a somewhat more common name - friendship.

Figure 3a: Friend section

Triton Green will use student's existing social networks to extend user groups through friending. As shown in Figure 3a, a “friends” section displays a list of Triton Green accounts that users have befriended. It should be pointed out that the friends' module does not allow for one-way friendships, where a user can follow others without having a mutual friendship. Instead, Triton Green requires users to opt-in if they accept a friend request or not. There are two ways to add friends on Triton Green: adding by searching for the user's name or scanning a QR code. If both of the users have activated their Triton Green accounts, they can tap on the "+" symbol on the top of the friend's list, select "Add Contacts," and search for a friend's name (as shown in Figure 3b). Users can also access within a frame to start scanning. Users can find their QR codes by tapping their photos on the home page.

Figure 3b: Adding Friends

Internal Triggers

Internal triggers associated with using Triton Green comes from students themselves. Negative emotions are powerful internal triggers that affect student lives (Eyal, 2014). Studies demonstrate that there is an increasing number of college students who are diagnosed with depression, anxiety, attention deficit hyperactivity disorder (ADHD), obsessive-compulsive disorder (OCD), and panic attacks (Crist, 2018). Another study, conducted by researchers at Missouri University, aimed to find out how internet activities provide psychological relief among college students. It shows that students with depressive symptoms had a high tendency to engage in internet services, including an increased amount of gaming and chatting (Kotikalapudi et al., 2012).

Triton Green would link its service with students' daily routines and emotions. As indicated in the commute survey, mobile social apps and smartphone games are frequently used among respondents in everyday life. Aligned with findings from psychology studies and the survey results, it is predictable that users would instantly open Triton Green, scroll through the list of their friends, visit their friend's homepage, and search for opportunities to steal carbon points when they feel bored, stressed, or lonely. Furthermore, the fear of losing points or missing the opportunity to take points from their friends would be a substantial internal incentive to bring Triton Green users back to the mobile app. Likewise, the fear of missing the chance to earn points by taking public transit or riding shared e-scooters would prompt users to opt for sustainable commute modes more often than driving alone to campus.

Positive emotions can also serve as internal triggers to use Triton Green, and they exist in need to satisfy what is bothering the users (Eyal, 2014). It can be inferred from the commute survey that students at UCSD are concerned about anthropogenic climate change, but they have not engaged enough in solving climate-related issues. Triton Green solves this problem via a social network game. In the game, users can earn carbon points by taking sustainable modes of transportations instead of using single-occupancy vehicles to travel to the UCSD campus. More details about the in-game feature of Triton Green will be discussed below. The internal triggers of engaging in tackling climate change, contributing to environmental protection, and realizing self-values will enhance users' loyalty to Triton Green that promotes low-carbon commute behavior via a carbon point system.

Action

Triggers are useless if users do not take action (Eyal, 2014). Therefore, the second phase in the Hooked Model – action is crucial when designing Triton Green. The Fogg Behavior Model provides guidelines to initiate the desired behavior (Fogg, 2019). Dr. Fogg (2019) states that motivation, ability, and prompt must appear simultaneously for any action to occur. Among the three elements, the prompt is the same as the trigger in the previous section, incentives drive the level of desire to act, and ability refers to the simplicity to implement an action (Fogg, 2019; Eyal, 2014).

Motivation

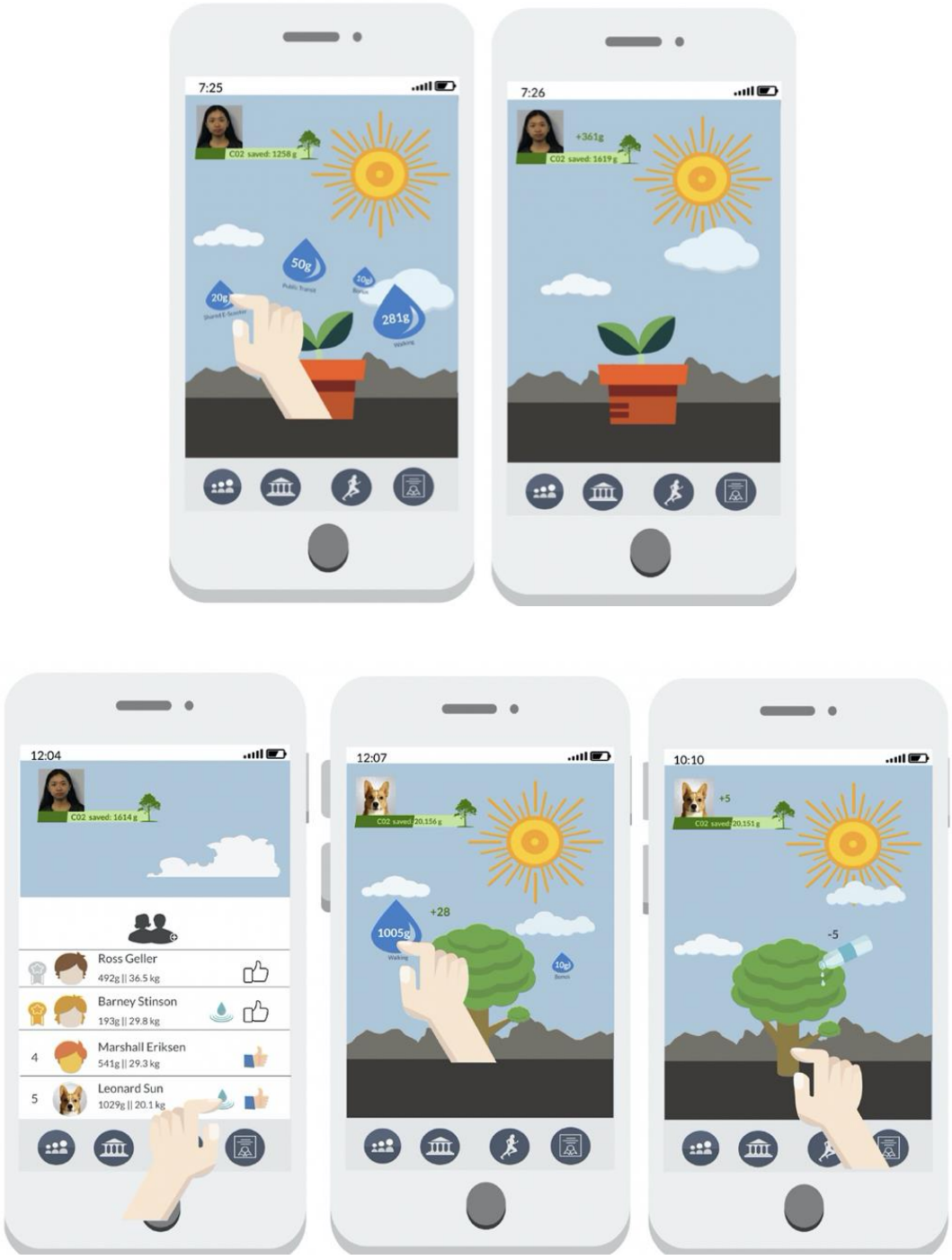
The Fogg behavior model highlights three motivators: sensation, anticipation, and belonging (Fogg, 2019). To be more specific, everyone is motivated to seek pleasure and avoid pain; to find hope and avoid fear; and to get social acceptance and avoid social rejection (Fogg, 2019; Eyal, 2014). Triton Green employs these motivators in the product building process.

Triton Green inspires users to reduce their transportation footprint by utilizing eco-friendly commute options, including taking regional buses and trolleys, riding shared electric scooters or bikes, and traveling on foot. Triton Green hopes to sow the seeds of green lifestyles and receive a low-carbon community. As indicated in Figure 4, users can claim carbon points for each pro-environmental action they have performed the previous day and save them to their personal carbon account.

Triton Green is also a social networking application as it enables users to collect points from their friends when a "drop" sign shows up, as demonstrated in Figure 4. These carbon points can be used to grow the user's virtual sapling or to be shared with friends by "watering" (as shown in Figure 4). Every time a user waters their friend's virtual plant, five points would be transferred from the user's account to his friend's. A user can water other's virtual plants no more than ten times a day. After users accumulate enough carbon points, they can redeem for various types of rewards, which will be discussed later in this section.

The game-like activity is the primary way that Triton Green motivates users to form carbon-reducing habits.

Figure 4: The Game



Psychological studies found that Likes on social media can help people to maintain interpersonal relationships, as they serve as cues of social acceptance (Scissors, Burke & Wengrovitz, 2016; Sherman, Payton, and Hernandez, 2016). In line with this idea, Triton Green affords such one-click feedback among users, as demonstrated in Figure 5. As in Figure 3b and Figure 5, user's efforts made in environmental protection by taking sustainable modes of transportation are presented as the amount of greenhouse gas saved daily and totally as well as the number of daily steps. Likes send a cue to the person who contributes to carbon emissions reduction, and to his network of friends for their endorsements. Research shows that people are more likely to engage in activities that have been endorsed by their close friends and romantic partners (Scissors, Burke & Wengrovitz, 2016; Start Digital, 2017). Likes are indicators of social standing (Start Digital, 2017). Based on observations in daily life, a good deal of Likes can build up self-esteem when someone is struggling with anxiety and depression. In this case, Likes can be treated as a sign of persistence engagement in low-carbon travel choices if users are looking at the number of Likes they have received.

Likes can also help Triton Green to extend the user base due to the "Like paradox" (Scissors, Burke & Wengrovitz, 2016). Since a user's friends may get more Likes as they have more friends to provide those Likes, he would tend to introduce Triton Green to those who have not activated the account to expand his network. Additionally, with the notification tab (as shown in Figure 5), users would form a habit to frequently open Triton Green and check who has liked them in a short period of time. Triton Green hopes to motivate users to stick to sustainable travel behavior through the thumbs up.

Calculate Carbon Points

Carbon points were calculated based on the assumption that every student at UCSD could have driven alone to campus instead of taking any green transportation modes. Per-mile emissions for different modes of transportation were calculated using the data from the American Bus Association, As shown in Table 6, on average, regional buses and trolleys emit 318 grams (0.7 pounds) of CO2 per passenger mile while single-occupancy vehicles emit 368 grams (0.81 pounds) (Bradley, 2014). Therefore, taking public transit can reduce 50 grams of CO2 for each mile traveled by a single commuter compared with driving alone. Accordingly, the 50 grams will be converted into 50 carbon points for each bus/trolley ride (as shown in Figure 4). Each user can receive carbon points from taking buses and trolleys no more than four times a day since the majority (88%) of the commute survey respondents transfer between buses or trolleys less than twice in a one-way trip.

Table 6: CO2 Emissions by Mode.

Mode	CO2 g/ pass-mi Low	CO2 g/ pass-mi Average	CO2 g/ pass-mi High
Motor Coach	41	43	46
Bus and Trolley	194	318	441
Car- 1 Person	170	368	566

Carbon emissions by walking are compared with that of the motor-coach. Bradley (2014) and his associates show that a motor coach produces the average carbon emissions of 43 grams per passenger mile, which is the lowest amount among all kinds of commute modes. For traveling on foot, per-mile emissions are assumed to be zero. Therefore, for an average individual, walking can reduce at least 43 grams of CO2 per mile traveled compared with any other mode of transportation. According to an estimated step to distance conversion,

an average person takes about 2,000 steps to walk one mile (University of Wyoming, 2004), so every step would save at least 0.0245 grams of C02. Thus, carbon points earned by walking equal to 0.0245 times the number of steps taken in a day. For example, a user took 1,1449 steps in a day, and so he can gain 281 carbon points for traveling on foot (as shown in Figure 4). Like walking, carbon emissions from traveling by shared bikes are also assumed to be zero. Thus, users can win 43 carbon points for each ride on shared bikes. However, research shows that shared e-scooters are not carbon-free (Samuel, 2019). Such commute mode emits more greenhouse gases than taking public transit, cycling, and walking, but less than driving alone (Samuel, 2019). In this case, users could get 20 points for each trip by shared e-scooters.

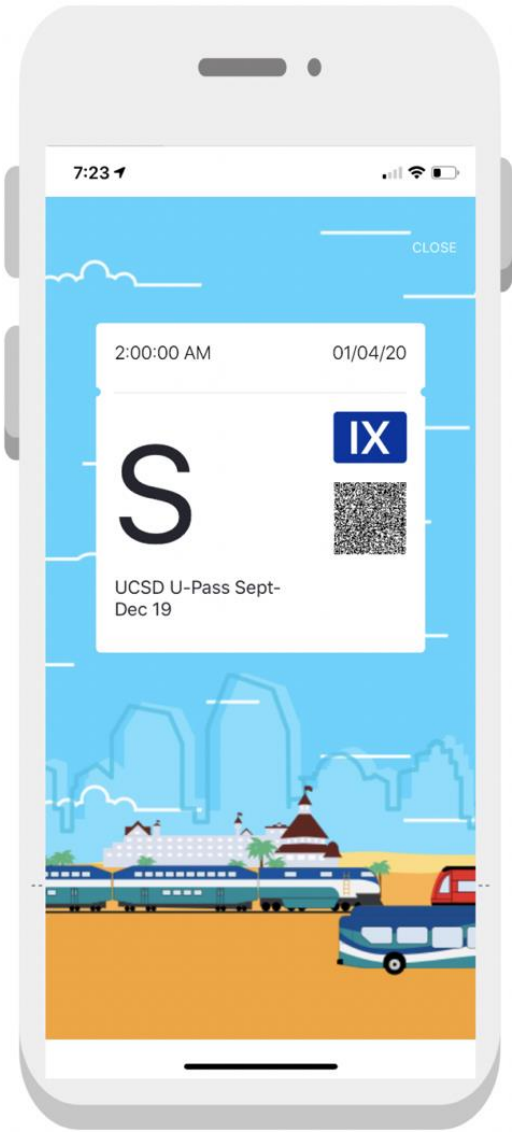
Walking is not just a recreational activity. Still, it can help with reducing carbon emissions, traffic congestion, and demand for oil (Center for Climate and Energy Solutions, n.d.). Walking also benefits health. Studies show that walking for at least a mile every day lowers the rate of fatal disease (Harvard Health, 2018). Therefore, Triton Green promotes walking as a part of green travel behavior. However, the commute survey results show that three in five of respondents have not formed the habit of tracking their daily steps on smartphones. Additionally, more than 70% of respondents walk less than ten thousand steps per day. In this case, Triton Green contains a module as a pedometer to help users to track their daily walk and record the number of steps to prompt healthy lifestyles, raise environmental awareness, and reduce personal carbon footprint. (as demonstrated in Figure 4 and Figure 5).

Figure 5: Tracking Daily Steps

Ability

The ability to accomplish a task easier increases the likelihood of that behavior to occur, before turning such behavior into habits (Eyal, 2014). According to the Fogg Behavior Model, the ability is the simplicity of a target behavior (Fogg, 2019; Eyal, 2014). Fogg (2019) demonstrates five elements of simplicity: time, money, physical effort, cognitive efforts, and routine.

Figure 6: Boarding Pass



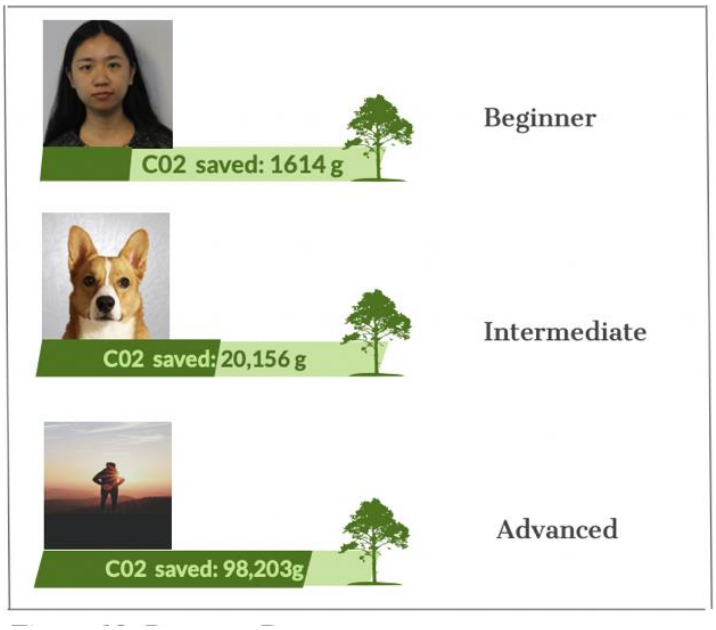
Research shows that getting feedback on the content users produced is the main reason for them to frequently check social media (Scissors, Burke & Wengrovitz, 2016). However, comments and messages usually require a lot of effort and context. Yet, Likes is crucial to social media users since it only takes one click to produce. Thus, Triton Green employed Likes rather than comments and messages to reduce the amount of time and cognitive efforts for endorsements.

As for Triton Green, the three promoted low-carbon commute behavior are easy to perform as they require little time and money investment from the users, no physical and mental efforts, and match the existing daily routines for most students at UCSD. Learned from the commute survey and observations that most students at UCSD show a bus pass displayed on their smartphone when boarding. The bus driver pushes a button next to the steering wheel to count the number of commuters on the bus. To calculate the number of bus rides each user takes every day, all users should do is to scan the QR code displayed on their smartphones when they get on board (as shown in Figure 6). Triton Green will receive the data from the

compass cloud mobile app, convert them into carbon points for users to collect the next day. The same happens when users scan QR codes with the Spin mobile app to take shared bikes or e-scooters. However, Triton Green would be hard to serve users who live more than 7.5 miles from campus since taking public transit, riding sharing bikes, and traveling on foot have increased of commute time and physical efforts compared to driving.

Concept of Heuristics

Figure 7: Progress Bar



Reinforcing motivation and ability spurs the likelihood of users performing desired behavior (Eyal, 2014). Therefore, concepts of heuristics are also employed in building Triton Green. The progress bar that displays the amount of carbon saved from sustainable commuting behavior was built according to the endowed progress effect (Eyal, 2014). As shown in Figure 7, every Triton Green user starts with some apparent progress. The progress bar increases as the users accumulating carbon points. However, since there is no numeric scale, new users might feel they are not far away to accomplish the goal. Yet, there are still efforts that advanced users can make. Scarcity effects were also employed to reinforce motivation. As it

is well known that a limited supply could increase sales (Eyal, 2014); only a finite number of rewards will be provided to improve competition among users.

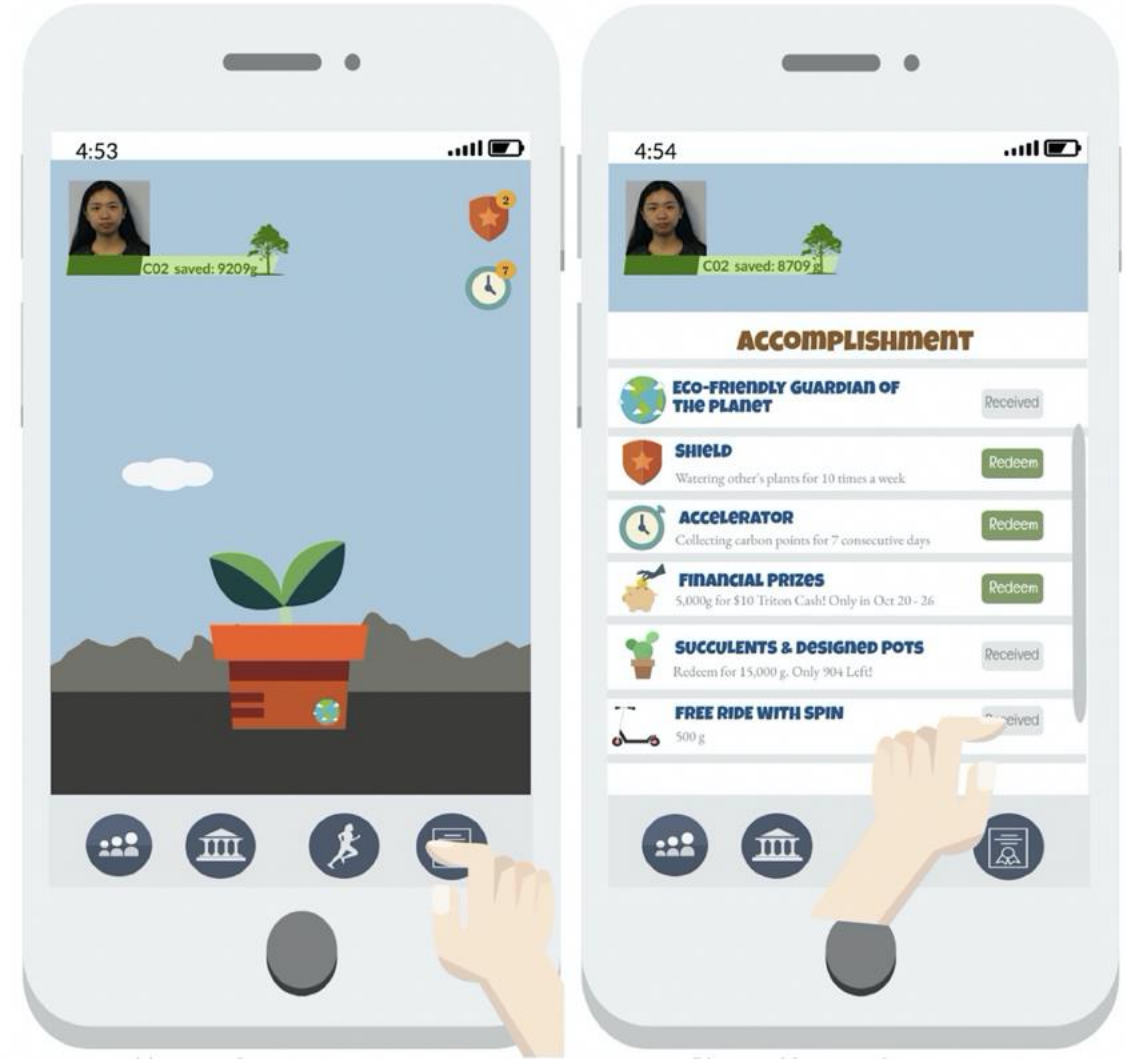
Rewards

Triton Green leads users at UCSD to contribute to achieving the carbon neutrality goal by 2025 via simple but incentive activities. However, to keep users engaged and motivated, variable rewards must be provided. There are three types of variable rewards: the tribe, the hunt, and the self (Eyal, 2014). Triton Green employed these types of variable rewards to reinforce the user's motivation to insist on performing pro-environmental commute behavior.

Rewards of the tribes, also known as social rewards, are driven by people's desire to be accepted and included by others (Eyal, 2014). Likes in Triton Green provides tribal validation for those who choose sustainable modes of transportation. Such social rewards encourage users to continue performing green travel behavior in daily life. Tribal rewards will also inspire more people to get involved in the initiative of reducing transportation emissions according to the Social Learning Theory. Bandura (1997) found that people learn from one another by observing other's behavior, attitudes, and outcomes of such actions. In this case, it is predictable that more students will be participants in reducing their transportation footprints after observing someone being rewarded for his green travel behavior.

The rewards of the hunt come from the pursuit of resources (Eyal, 2014). In Triton Green, a user can scroll the list of their friends and “steal” carbon points from them when a sign of drop shows up (as demonstrated in Figure 4). By awarding random carbon points from their friends, such games of chance will attract users with the anticipation to hit the jackpot.

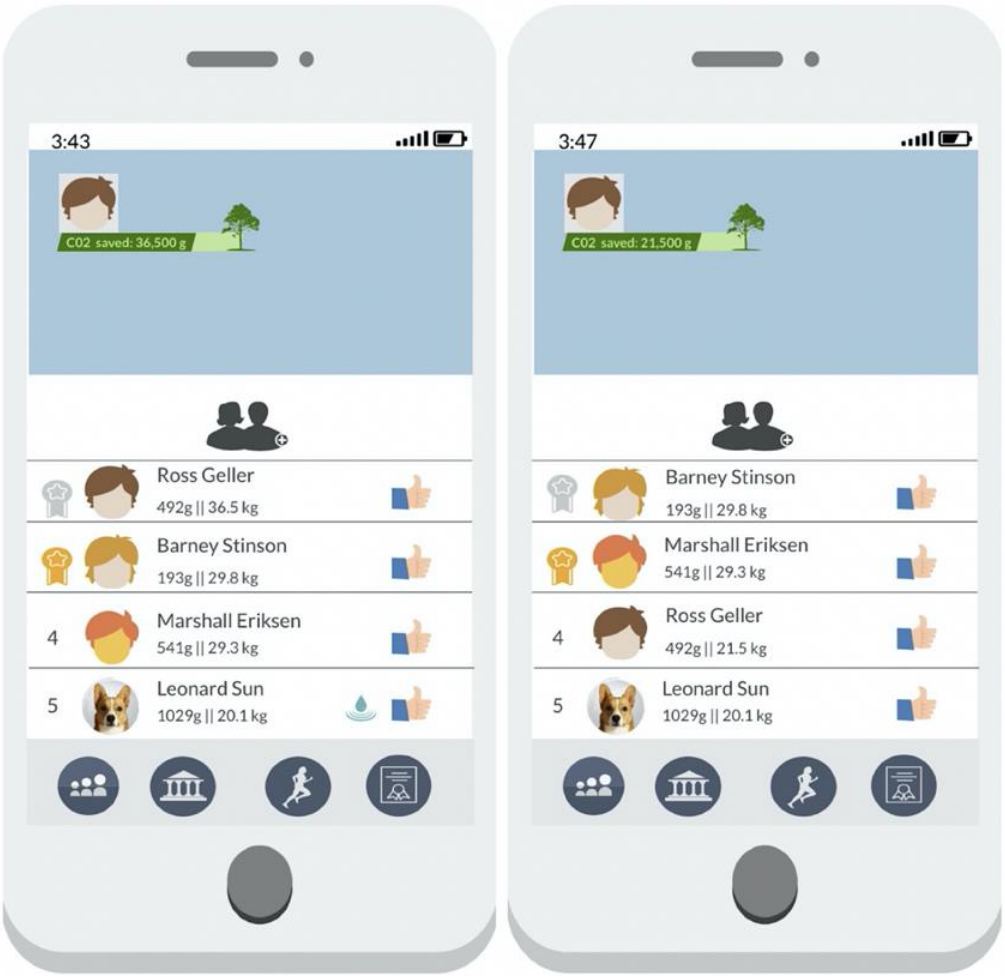
Figure 8a: Variable Rewards



Hunting for variable rewards will urge users to keep coming back to Triton Green. As shown in Figure 8, users can receive game items - shield when they collect carbon points for a consecutive seven days. Users can also get accelerators, as another type of game item, if they help their friends to water the virtual plants for at least ten times per week.

According to the commute behavior survey, a lot of respondents were unwilling to ride with other modes of transportation because they thought such transportation modes were more expensive than driving alone. However, all respondents mentioned that both monetary and in-kind prizes would motivate them to try a greener commute style. Therefore, various types of financial and in-kind prizes, such as Triton Cash, UC San Diego Bookstore gift card, free rides with Spin, Lyft discounts, and succulent plants with designed pots, will be provided when users reach certain point levels. For example, as indicated in Figure 8b, user Ross has accumulated 36,500g of carbon points. He can save the points in his account or redeem for different prizes. Assume Ross redeemed 15,000g for a succulent plant with a designed pot, there would be 21,500g carbon points left in his carbon account, and his position in the friend's list would move downward correspondingly. Assume that to hunt for more rewards, Ross would continue use green travel modes and accumulate additional carbon points in his account. The purpose of changes is to keep users who rank at the top of the friend's list continuously engaged in sustainable travel behavior.

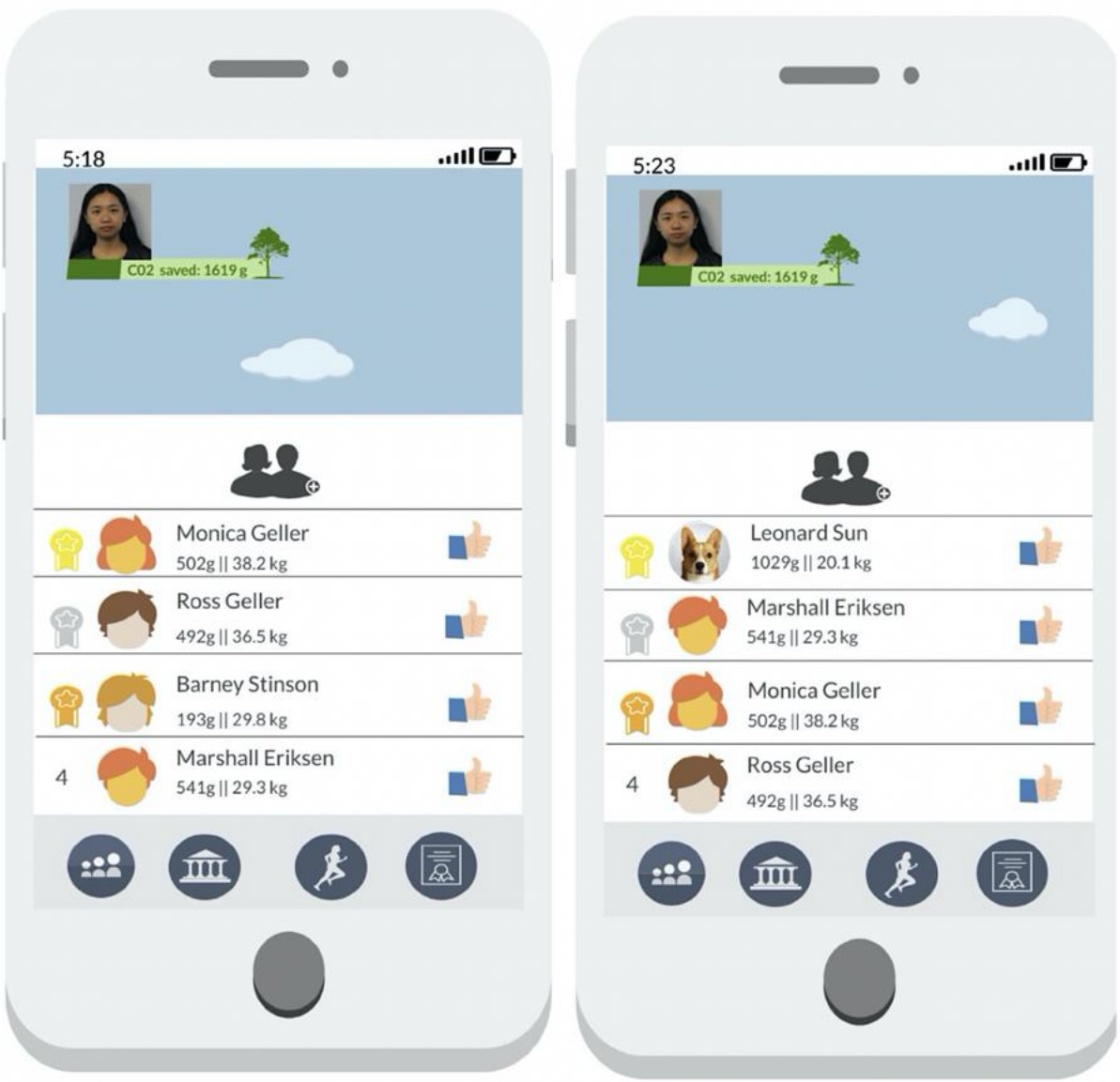
Figure 8b: Variable Rewards: Likes



Rewards of the self are driven by intrinsic incentives (Eyal, 2014). The self-determination theory states that people are eager to pursue mastery, competence, and completion (Deci & Ryan, 2008). Users will find satisfaction in contributing to tackling climate change issues from the progress bar on their homepage. They will also feel rewarded as they receive Likes for each low-carbon trip and redeem carbon points for a diversity of prizes. By these means, Triton Green delivers a feeling of mastery and completion. To fulfill the desire of competency, Triton Green helps users to track the amount of carbon they saved from

sustainable commute behavior and displays their daily and totally contributions in descending orders (as demonstrated in Figure 9).

Figure 9: Ranking

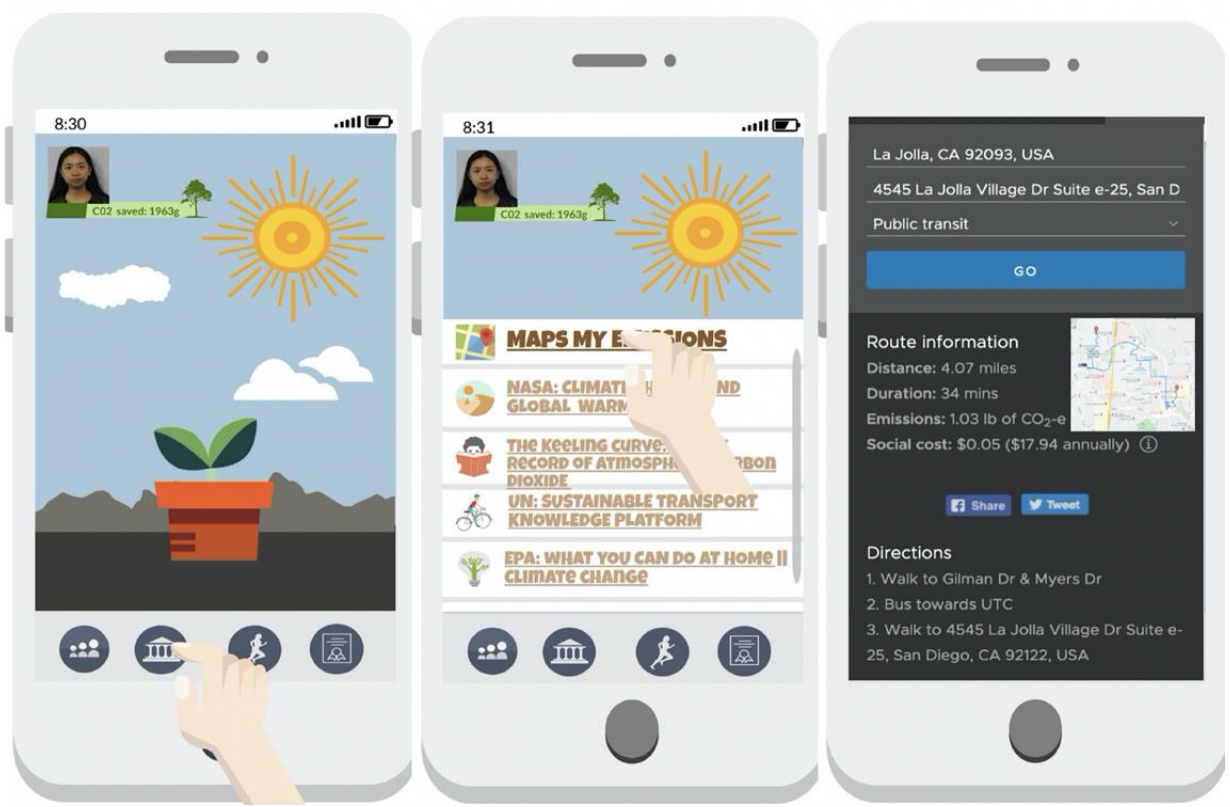


Investment

According to Eyal (2014), investment is the last phase in the Hooked Model. The association between Triton Green and sustainable commute habit is not formed overnight. The point system and variable rewards encourage users to make persistent efforts in eco-friendly transportation options. Besides, as demonstrated in figure 16a, Triton Green offers an educational module to encourage users to invest some time in learning about anthropogenic climate change. Users can find climate-related websites and articles in that module.

For instance, Triton Green will link the Map My Emissions, which enables users to compare the greenhouse gas emissions with different modes of Transportation. As shown in Figure 16c, users can enter their initial locations as well as the final destination and choose a commute mode. Map My Emissions (n.d.) will calculate the carbon emissions, commute miles, and commute time associated with each trip. However, unlike Triton Green, Map My Emissions does not motivate users to choose from low-carbon travel options. Instead, it merely offers information. With users' sustaining investments, Triton Green hopes to store the value of green travel behavior and then set future triggers for other low-carbon behavior, such as recycling.

Figure 10: Educational Section



DISCUSSION

UC San Diego has committed to reduce single-occupancy vehicle (SOV) commute rates by 10% relative to its 2015 levels before 2025 (UC San Diego Sustainability, 2019). Triton Green provides an alternative approach to help the university to meet its carbon reduction targets. Currently, the university has offered several green commuting and transportation programs, such as the Pedal Club for campus bicycle commuters, U-pass for students who are public transit riders, Lyft FLEX Shared program, and Zipcar car-sharing service, to avoided driving and parking on campus (UC San Diego Sustainability, 2019). However,

many of these programs only provide monetary incentives to encourage students, faculty, and staff to use green travel modes instead of SOV. For example, students, faulty, and staff can purchase Lyft FLEX Shared credits. With these credits, they can pay up to 60% less when they agree to share their Lyft with another passenger (UC San Diego Transportation Services, 2019). By contrast, Triton Green offers variable rewards in addition to monetary prizes, including social rewards (likes), in-kind prizes (succulent plants), and self-rewards (a sense of mastery and completion) to better engage students to participate in the campus-wide initiatives to achieve carbon neutrality.

Unlike conventional ways that governments and environmental lobbies advocate the importance of reducing carbon emissions by delivering the information in a one-way communication, Triton Green brings social networking into play. By watering friends' virtual plants to giving them carbon points, the collective power of social relationships will be strengthened. Users will also have a sense of how much efforts they have made to reduce personal transportation footprint compared with their friends from the ranking list. Users are expected to be more likely to engage in green commute behavior and further commit to pro-environmental lifestyles while experiencing the comparative and competitive interactions with their friends. Triton Green hopes to change the public from passive audiences of climate change to active contributors through participatory experiences like what Ant Forest has already achieved. However, in the initial stage of Triton Green, several limitations remain to be addressed in the future.

Limitations

At present, Triton Green only promotes three sustainable commute behaviors, including walking, riding shared bikes and electric scooters, and taking public transit. The limitation of options in pro-environmental behaviors in the game might discourage users to continue committing to Triton Green in the short run. In this case, more low-carbon activities, such as recycling plastic and paper materials and utilizing reusable dishes in dining halls, will be adopted into the list of pro-environmental actions that Triton Green means to promote. Moreover, new game mechanisms and diverse rewards need to be integrated into Triton Green in the future to distinguish the app from Ant Forest, avoid boredom, and keep users motivated.

There is a possibility that no tangible changes will occur in students' commute behavior as expected. Long commute distance and time, the lack of reasonable commute alternatives other than driving alone, and irregular hours on campus all prevent students from switching to sustainable modes of transportation. Triton Green is incapable of addressing these issues. It is possible that Triton Green will only change the behavior of marginal commuters who have access to green transportation options but prefer driving their own cars to campus. For students who have already been green commuters and taken pro-environmental modes of transportation as their primary choices, Triton Green merely serves as an incentive for them to keep committing to the existing green travel behavior.

In comparing the group of students who treat sustainable commute modes as reasonable alternatives of SOV usage with the group of students who have already engaged in sustainable travel behavior, Triton Green's rewards system seems to be problematic for offering both of the groups the same rewards.

Suppose Leonard usually takes buses to campus five days a week, while Penny drives alone three times and takes buses twice a week to campus. After launching Triton Green, Leonard continues his commute routine and will receive 250 points for taking buses. On the other hand, Penny changes her commute behavior and takes buses twice more than usual while driving two times less per week. As a result, Penny will receive 200 points for four rides with public transit. However, only 100 points are awarded for her changes of commute behavior as she uses SOV twice less than usual. Considering the trade-off like time sacrificed on the road and the differences in the points received compared with Leonard, the current calculation of carbon points may not be motivating enough for students like Penny to indeed change their commute behavior.

Triton Green may not reduce greenhouse emissions by rewarding the number of daily steps as well. Students who rank at the top in the friends list in the walking section may not necessarily be those who reduce their carbon footprint by walking between destinations on or off campus more often. However, Triton Green still rewards users for the number of daily steps they take to promote a healthy lifestyle, and for the possibility that they would

choose to walk instead of SOV for a walkable commute trip to reduce personal transportation emission.

Most importantly, Triton Green fails to set up the baseline travel due to the complexity and diversity of individuals. Therefore, it is hard to monitor and analyze the effectiveness of Triton Green in greenhouse gas emission mitigation based on the app alone. For future studies, the baseline trip could be established based on the campus parking space inventories before and after the launch of Triton Green even though individuals may not reveal their diverse travel preferences due to privacy. Since Triton Green has limited abilities to address all of the issues discussed above, it can only serve as a possible method to reduce campus transportation emissions by inspiring users to switch to pro-environmental lifestyles as well as providing information about how personal transportation emission would change with different modes of transport in a course of interactive game and variable rewards. Ultimately, individuals choose their journey.

RECOMMENDATIONS

The 2019 commute behavior survey shows an inconsistency in personal climate change beliefs and daily commute behavior. Long commute time and distance are the primary obstacles that prevent respondents from utilizing green commute modes. Moreover, a lack of bike lines and sidewalks, limited parking spaces for shared bikes or e-scooters near

working locations, no access to public transit, long distances from a bus stop, and long waiting periods at the bus stop also emerged as obstacles in the survey results. Such infrastructure barriers make it difficult to engage the public in green travel behaviors by Triton Green alone.

Every year, public transit saves more than 37 million metric tons of carbon dioxide emissions in the United States (American Public Transportation Association, 2019). A study shows that if the usage of public transit increases to 40 percent by 2025, 26.3 giga tons of carbon dioxide equivalent ($MTCO_2e$) would be mitigated by 2050 (U.S. Department of Transportation, 2010). Due to the massive greenhouse gas reduction potential by taking public transit, Triton Green encourages users to get out of their cars and onto buses and trolleys by a point system and variable rewards.

To collect the data about public transit ridership, QR code scanners are required to be installed in each of the transit buses. Both survey and daily observations show that most students show a pass, which includes a QR code, displayed on their smartphone when boarding. The bus driver then pushes a button next to the steering wheel to count the number of commuters on the bus. QR code scanners can not only provide ridership data before and after the launch of Triton Green to analyze the effectiveness of the app, but also reduce the workload of bus drivers. For bus riders, scanning the QR code on smartphones when boarding has no difference with showing the pass to a driver. Thus, the task is easy to accomplish by riders without physical and cognitive efforts. However, financial

investments are needed. The money can come from subsidies from campus parking fees and students' fees (UC San Diego, 2019).

Inconvenience is a critical obstacle with increasing the ridership of public transit from a single-occupancy vehicle usage. Respondents who live within a five-mile radius from campus complained about long waiting periods at a bus station. Thus, increasing the bus frequency could encourage those marginal commuters to take public transit more often. Respondents also indicated that long distance to a transit station discouraged them from traveling with buses and trolleys. More than half of the respondents (56%) claimed that they were unwilling to walk more than a half-mile to catch a bus. In this case, a combination of public transit and bikes/e-scooter share programs could be considered. Racks and lockers of shared bikes and e-scooters can be built near transit stops, transit transfer centers, major buildings on campus, and major residential areas off campus so that commuters can bike to and from public transit. The connection of public transit and bike and e-scooters sharing programs reduces the walking distances of commuters, and it may increase the ridership of both shared electric scooters and public transit

Respondents also indicated that they would be more willing to travel with regional buses and trolleys to campus if there were new bus routes and express buses near where they live. Therefore, expanding public-transit infrastructure could overcome such barriers and encourage students to take public transit more often. The city of San Diego has paid attention to its transit corridors, aiming to boost public transit ridership to curb

greenhouse gas emissions. However, the detailed plan to meet its targets to reduce carbon emissions from transportation was unclear (Smith, 2016). In this case, campus leaders are required to maintain a strong partnership with agencies like the San Diego Metropolitan Transit System and SANDAG to develop strategies to improve the service and infrastructure of public transit.

Even though electric scooters have higher carbon emissions than regular bikes due to the battery that helps scooters to travel faster and for longer distances, 7.1 $MTCO_2e$ would be avoided if commute distance on e-scooters was increased from 249 billion miles traveled in 2014 to 1.2 trillion miles traveled per year by 2050 (U.S. Department of Transportation, 2010). In 2017, UC San Diego was partnered with Spin to launch a bike-share partnership pilot program as a part of a university-wide initiative to become carbon neutral by 2025.

However, shared bikes and e-scooters are not very popular among graduate students who took the 2019 commute behavior survey, as only 28% of them have ever taken shared bikes and e-scooters. Respondents were concerned about personal safety, limited parking spaces, and accessibility of shared bikes and e-scooters on campus. Some respondents also complained that riding shared e-scooters was inconvenient. If respondents took shared e-scooters off-campus, they had to return the e-scooters back to campus in a timely manner the same day. Others indicated that without docks or locks, the shared bike and e-scooters were easy to pick up and went with just an app download. It was easier to leave them anywhere and everywhere, but hard to find when they were actually needed. Therefore,

bike or e-scooter racks and lockers need to be established near transit stops, transit transfer centers, and major buildings on and off campus. In this case, commuters could have easy access to the shared bikes and e-scooters, and program managers could regulate the shared bikes and e-scooters that are left randomly on the street. As mentioned previously, increases in the accessibility of shared bikes and e-scooters can improve the convenience of taking public transit as well. Furthermore, a protected bike path could be built to improve personal security.

In addition, the commute survey indicates that 54% of the graduate students who completed the survey live more than 2.5 miles from the campus. To reduce the need for students to travel to campus, additional affordable housing is required to be built near UC San Diego. However, the potential greenhouse gas emissions from the increased campus infrastructures have to be considered, even though more campus residents may reduce transportation emissions.

CONCLUSION

Transportation is one of the primary sources of greenhouse gases that warm the planet (United States Environmental Protection Agency, 2019). To avoid the most devastating consequences of anthropological climate change, universities, businesses, governments, states, and countries have made ambitious commitments to reduce greenhouse gas

emissions. Behavior change can help to curb greenhouse gas emissions at the individual level.

The capstone project provides a bottom-up approach – Triton Green to encourage students at UC San Diego to participate in the campus-wide initiatives to achieve carbon neutrality. To better understand the commute behavior and habits of students, a survey was conducted before designing the app. Survey results show that a majority of respondents use sustainable modes of transportation when traveling to campus. However, due to lack of reasonable commute options, irregular hours on campus, and longer commute time of any other commute mode, respondents choose to commute by SOV instead. Respondents were willing to switch to a sustainable mode of transportation if they were provided with monetary prizes like student discounts and in-kind prizes like succulent plants. Concerns about the environment, limited parking spaces and high cost of parking permits could discourage respondents to drive alone to get to work or class. Moreover, most respondents in the survey believe in anthropologic climate change. However, an inconsistency between personal climate change beliefs and daily commute behavior exists. Infrastructure barriers that prevent respondents from traveling with green commute mode are hard to be addressed by Triton Green alone. Therefore, other recommendations, such as expending public-transit infrastructure, increasing bus frequency, and building affordable graduate housing near campus are provided. Triton Green used some of the survey results in the product-design process.

Triton Green aims to promote a sustainable community around the UC San Diego campus. It is envisioned as a pervasive and ubiquitous platform that combines mobile technology, psychological incentives, cooperative and competitive gamification, and social-media to empower and reward students at UC San Diego to reduce their carbon footprint from transportation. Through a game-playing experience, users are expected to learn what actions are environmentally friendly as they are rewarded with points, likes, and financial as well as in-kind prizes for opting-in to pro-environmental commute behaviors. Since social-networking apps are the most popular among students, Triton Green also brings it into play. From watering friends' virtual plants, the collective power of social relationships would be strengthened. Users are also expected to be more likely to engage in green commute behavior and further commit to pro-environmental lifestyles while experiencing the comparative and competitive interactions with their friends. However, at the initial stage, several issues, such as the failure to set up baseline trips, needs to be addressed for future studies. At present, Triton Green is only a potential alternative to reduce greenhouse emissions from the transportation section. It could inspire users to switch to pro-environmental lifestyles. Getting out of cars and onto green modes of transportation is one small step for a man, one giant leap for mankind.

APPENDIX A

Commute Behavior Survey Questionnaire

Hello, my name is Linchang Li. I am a Climate Science and Policy M.A.S. student at Scripps Institution of Oceanography-UCSD. As part of my capstone project, I am conducting research into travel behavior and climate change opinions and kindly ask for your time to reflect on your transportation choices and habits while you are here on the UCSD campuses.

If you agree to participate in this study, you will be asked to complete a survey containing 6 parts and will take approximately 5 to 10 minutes to complete.

Research records will be kept confidential to the extent allowed by law. Your responses will be combined with those of other participants. Participation in research is entirely voluntary. You may refuse to participate or withdraw at any time without a penalty or loss of benefits to which you are entitled.

As a thank you for your participation, I will be providing a $25.00 Amazon eGift card to the first ten participants, a $15 Amazon eGift card to the 11th to the 30th participants, a $10 Amazon eGift card to the 31st to the 60th participants, and a $5 Amazon eGift card to the 61st to the 100th participants in the survey. Please provide your email at the end of the survey to indicate your interest in the gift card. The Amazon eGift cards will be sent via emails by the end of Fall quarter 2019.

If you want additional information or have questions or research-related problems, you may reach Linchang Li at lil248@ucsd.edu.

Part 1. MY COMMUTE TO UCSD CAMPUS

Current Commute Patterns

Please answer the following questions about your typical commute to the UCSD campus.

1. **Commute Miles.** How far do you live from the UCSD campus?
    a. Less than 2.5 miles
    b. 2.5 – 5 miles
    c. 5.1 – 7.5 miles
    d. 7.6 – 10 miles
    e. More than 10 miles

2. **Commute Time.** On a typical day, how long does it take you (including traffic delays) to make a one-way trip to/from the UCSD campus?
    a. Less than 15 minutes
    b. 15-30 minutes
    c. 31-45 minutes
    d. More than 45 minutes

3. **Work/Class Schedule.** How many days a week do you typically travel to the UCSD campus for work/class?

    a. Less than once a week
    b. 1 – 2 days a week
    c. 3 – 5 days a week
    d. 6 – 7 days a week

4. **Commute Mode.** In a typical week, please check the mode that you most often use to travel to/from the UCSD campus?

    a. Walk

    b. Drive myself alone

    c. Bike/ Scooter (WITHOUT public transit)

    d. Bike/ Scooter (WITH public transit)

    e. Public transit (including MTS buses & trolley and NCTD Breeze buses)

    a. Carpool/Vanpool/ On-demand rideshare service like Uber and Lyft.

    f. Campus Shuttle

    g. Other, (please specify) _____

5. **Past Travel Frequency.** Approximately how many days did you use each type of transportation to get to/from the UCSD campus in the **past week (Oct 21-27, 2019)**

Mode	0	1-2 days	3-4 days	5 days	6-7 days
Walk					
Drive myself alone					
Carpool/Vanpool/ On-demand rideshare service like Uber and Lyft					
Bike WITHOUT public transit					
Bike WITH public transit					
Bikeshare WITHOUT public transit					
Bikeshare WITH public transit					
E-Scooter/ e-Bike share WITHOUT public transit					
E-Scooter/e-Bike share WITH public transit					
Public transit (including MTS buses & trolley and NCTD Breeze buses)					
Campus Shuttle					

Part 2. INTRA-CAMPUS COMMUTE

1. **Intra-campus travel frequency.** In addition to your daily walk to and from the parking areas to your primary campus location (e.g., your office), how frequently do you travel from one on-campus destination to another on-campus destination?

    a. Once a day

    b. 2-3 times a day

    c. 4-5 times a day

    d. More than 5 times a day

2. **Intra-campus travel purpose.** What is the primary purpose for most of your travel around the campus to other destinations? Please choose **ONE** that is the most relevant to you.

    a. To go for meals

    b. To exercise

    c. To attend classes among different buildings

d. To attend off-site school-related meetings or other tasks

e. To run other personal errands

f. Other, (please specify) _____

3. **Intra-campus travel mode**. For the intra-campus travel you selected in the previous question, what is your primary mode of transportation to make that trip? Please choose **ONE** that is the most relevant to you.

   a. Walk

   b. Drive myself alone

   c. Bike/ Scooter (WITHOUT public transit)

   d. Bike/ Scooter (WITH public transit)

   e. Public transit (including MTS buses & trolley and NCTD Breeze buses)

   f. Carpool/Vanpool/ On-demand rideshare service like Uber and Lyft.

   g. Campus Shuttle

   h. Other, (please specify) _____

Part 3. TRANSPORTATION MODES

A. Travel by Public Transit (including MTS buses & trolley and NCTD Breeze buses)

1. Have you ever taken public transit to/from/around the UCSD campus? If you choose NO, please skip Q3 – Q10.
   a. Yes
   b. No

2. Do you participate in the MTS U-Pass Program?
   a. Yes
   b. No
   c. I don't know

3. What do you perceive as being the most beneficial aspect about taking public transit to/from the UCSD campus?
    a. Cheaper than driving myself alone
    b. Cheaper than other transport modes
    c. Preferred bus to walking/riding a bike/scooter
    d. More convenient than driving myself alone (e.g. parking is difficult to find on campus)
    e. To reduce my carbon footprint
    f. Other, (please specify) _____

4. On boarding the bus, did you?
    a. Use cash to buy a ticket/ pass
    b. Use credit/debit card to buy a ticket/pass
    c. Show the driver a ticket/pass displayed on your smart phone
    d. Show the driver a paper ticket/pass
    e. Place the compass card onto the fare machine
    f. Don't recall

5. How many times do you transfer between buses on a one-way trip to/ from the UCSD campus?
    a. Never
    b. 1 time
    c. 2 times
    d. 3 times or more

6. On days that you took buses to/from the UCSD campus, how often did you take a bike/scooter (including shared bikes/e-Scooters) to the bus stop?
    a. Always
    b. Sometimes
    c. Never

7. What is the farthest distance you would be willing to walk or bike (including bike/ scooter sharing services) to a bus stop?
    a. ¼ miles
    b. ½ miles
    c. 1 mile
    d. More than 1 mile

8. Thinking about your time you spent on taking a regional bus/trolley to/from the UCSD campus, which of the following statements do you most agree with? Please choose **ONE** that is most relevant to you.
    a. I made very worthwhile use of my time.
    b. I made some use of my time.
    c. My time spent on traveling with regional buses/ trolleys was a waste of time.

9. Thinking about taking a regional bus to/from the UCSD campus, please indicate how satisfied you were with the following

Feature	Survey Scale: 0 = Completely Dissatisfied 5= Completely Satisfied					
Bus schedule	0	1	2	3	4	5
Bus route	0	1	2	3	4	5
On-time departures	0	1	2	3	4	5
The length of time it took to wait for your bus	0	1	2	3	4	5
Cleanliness/condition inside the bus	0	1	2	3	4	5
Availability of seating/standing spaces	0	1	2	3	4	5
Personal space	0	1	2	3	4	5
Personal safety	0	1	2	3	4	5
Driver	0	1	2	3	4	5

10. Which of the following would encourage you to take public transit more often to/from the UCSD campus? Select **ALL** that apply.
    a. To save money
    b. To reduce my personal carbon footprint and conserve energy
    c. To receive financial prizes (e.g. Free bus tickets and Amazon eGift cards)
    d. To receive in-kind prizes (e.g. Real saplings and designed mugs)
    e. To pursue self-accomplishment
    f. Other, (please specify) _____

B. Drive Myself Alone to/from the UCSD Campus

1. Do you usually drive alone more than once per month to/from the UCSD campus ? If you choose NO, please skip Q2 – Q10.
    a. Yes

b. No

2. What are your reasons for driving to the UCSD campus alone? Select **ALL** that apply.
    a. Prefer to drive my own car
    b. Live far (more than 5 miles) from the UCSD campus
    c. No reasonable transit options
    d. Personal Safety
    e. Anything else takes too much time
    f. Need to run errands before/ after work/school
    g. Irregular hours on campus
    h. Other, (please specify) _____

3. When you drive yourself to the UCSD campus, where do you usually park?
    a. Parking lot/garage on campus
    b. Public parking lot off campus
    c. Metered street parking
    d. Free street parking
    e. Other, (please specify) _____

4. How much do you pay for school-related parking every month? As in US dollars.

    _____

5. What might discourage you from driving yourself more often to the UCSD campus? Select **ALL** that apply.
    a. The cost of the parking permit is high
    b. There are limited parking spaces on campus
    c. Safety concerns
    d. Environmental concerns
    e. Other, (please specify) _____

6. What, if anything, prevents you from walking to/from the UCSD campus more often? Select **ALL** that apply.

a. Distance

b. Time

c. Personal safety

d. No sidewalk

e. Lack motivation

f. No limiting factors

g. Other, (please specify) _____

7. What, if anything, prevents you from taking public transit to/from the UCSD campus more often? Select **ALL** that apply.
    a. Cost
    b. Personal safety
    c. Length of ride
    d. Distance to bus stop
    e. Delayed on board due to traffic
    f. Experienced long wait at the bus stop
    g. Missed departure due to wrong real-time information
    h. Unable to board or denied boarding due to crowding
    i. I have no motivation to take a bus to school
    j. Other, (please specify) _____

8. What, if anything, prevents you from using a rideshare service (e.g. Uber and Lyft) to/from the UCSD campus more often? Select **ALL** that apply.

    a. Cost

    b. Safety concerns

    c. Unreliable

    d. Unavailable for my trip

    e. I have no motivation to use ridesharing to school

    f. Other, (please specify) _____

9. If you were to use a mode of transportation other than driving alone to the UCSD campus, which of the following would work best for you?

    a. Walk

    b. Bike/e-Scooter WITHOUT public transit

    c. Bike/e-Scooter WITH public transit

    d. Bus, including MTS buses & trolley and NCTD Breeze buses

    e. Carpool/Vanpool/ On-demand rideshare service like Uber and Lyft

C. Spin Shared Bikes and e-Scooters

1. Have you ever ridden a shared bike/e-Bikes/ e-Scooters to/from/around the UCSD campus?
    a. Yes
    b. No

2. What do you perceive as being beneficial aspects about riding a shared bike/e-Scooter/e-Bike to/from/around the UCSD campus? Select **ALL** that reply

    a. Cheap travel costs

    b. For health & fitness

    c. Time savings

    d. Convenience

    e. Environment-friendly

    f. So that I do not have to bring my bicycle/skateboard/scooter to school

    g. So that I can switch to a public transit commute and stop driving to school

    h. Other, (please specify) _____

3. What, if anything, prevents you from riding a shared bike/e-Scooter/e-Bike to/from the UCSD campus more often? Select **ALL** that apply.

    a. Distance

    b. Time

c. Cost

d. Personal safety

e. Inconvenience (e.g. If I take a shared bike or e-Scooter off campus, I have to return it in a timely manner to campus the same day)

f. Hard to find available shared bikes/e-Scooters/e-Bikes

g. No bike lane

h. No parking spots

i. Lack motivation

j. No limiting factors

k. Other, (please specify) _____

4. Which of the following would encourage you to use shared bikes/ e-bikes/e-Scooters more often?
    a. Financial prizes (e.g. Free ride)
    b. In-kind prizes (e.g. Real saplings and designed mugs)
    c. Other, (please specify) _____

Part 4. SMART PHONE USE

1. How often do you use the UC San Diego mobile app on your smartphone?
    a. Never
    b. Rarely
    c. Sometimes
    d. Very often
    e. Always

2. What type of mobile apps do you use regularly on your smartphone? Select **ALL** that apply
    a. Games
    b. Music
    c. Health & Fitness
    d. Social networking
    e. Travel (e.g. Compass Cloud, Spin, Lime, Uber, and Lyft)

f. Other, (please specify) _____

3. How often do you show your U-Pass/bus ticket displayed on the Compass Cloud mobile app when traveling with regional buses/ trolley?
    a. Never
    b. Rarely
    c. Sometimes
    d. Very often
    e. Always

4. Do you use an app to track your daily steps? If you do NOT use an app to track your daily steps, please skip Q7.
    a. Yes
    b. No

5. Approximately how many steps do you typically take in a given day?
    a. Less than 1000 steps
    b. 1,001 – 5,000 steps
    c. 5,001 – 10,000 steps
    d. More than 10,000 steps

Part 5. CLIMATE CHANGE ATTITUDES AND OPINIONS

For each of the following statement, please circle the numeric response that best describes how strongly you agree or disagree.

Question	Survey Scale: 0=Strongly Disagree, while 5= Strongly Agree					
Climate change is NOT happening.	0	1	2	3	4	5
Climate change (since the Industrial Revolution) is caused by human activities, fossil fuel burning in particular.	0	1	2	3	4	5
I am concerned about climate change.	0	1	2	3	4	5
I think most of the concerns about climate change have been exaggerated.	0	1	2	3	4	5
Protecting the environment is more important than economic growth.	0	1	2	3	4	5
Government is responsible for addressing climate change issues in the United States.	0	1	2	3	4	5
I have engaged enough in the actions on combating climate change.	0	1	2	3	4	5
Tracking my personal carbon footprint can help me to reduce my daily carbon emissions.						
Individual's daily low-carbon activities can make a positive impact on climate change.	0	1	2	3	4	5
I will take public transit more often to school to reduce my personal carbon footprint.	0	1	2	3	4	5
I will use shared bikes/scooters more often to/ from the UCSD campus to reduce my personal carbon footprint.	0	1	2	3	4	5
I would drive myself less to/ from the UCSD campus to reduce my personal carbon footprint if I was provided an alternative mode of transportation.	0	1	2	3	4	5

Part 6. ABOUT YOU

1. What is your age?
    a. Under 21
    b. 21-24
    c. 25-28
    d. 29-32
    e. Over 33

2. With what gender do you most identify?
    a. Male

b. Female

c. Prefer to self-describe: _____

d. Prefer not to answer

3. You are currently a…

a. Masters

b. Doctorate/ PhD

c. Other, (please specify) _____

4. Which department/division do you belong to? (For graduate students)

a. Division of Arts & Humanities
b. Division of Biological Sciences
c. Division of Physical Sciences
d. Division of Social Sciences
e. Health Sciences
f. Scripps Institution of Oceanography
g. School of Global Policy and Strategy
h. Other, (please specify) _____

Thank you for your participation! Please provide your email address to be entered below to win an Amazon eGift card _____

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